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M26ccts safety study of  
1989 accident locations  
in Cascade County,  
Montana

1989

TRAFFIC SAFETY STUDY

OF

ACCIDENT LOCATIONS

IN

CASCADE COUNTY, MONTANA

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FINAL REPORT

October 26, 1989

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**HKM Associates  
Engineers/Planners**

Airport Industrial Park  
P.O. Box 31318  
Billings, Montana 59107  
Phone (406) 245-6354/259-1993  
Fax (406) 252-3757

Branch Offices:  
Bozeman, Montana  
Sheridan, Wyoming

October 26, 1989  
2M144.103/WPTRANS1427

Mr. Ken Jorgensen  
Cascade County Road Supervisor  
415 3rd Street NW  
Great Falls, MT 59401

RE: 1989 Cascade County Traffic Safety Study  
Department of Justice Contract No. 89-06-02-1

Dear Mr. Jorgensen:

We are pleased to submit 10 copies of the final report concerning the study of high hazard locations in Cascade County. This report conforms to our agreement with Cascade County dated July 7, 1989, except the V/C indicator value has been deleted from the study. This is in conformance with the outcome of the September 12, 1989 meeting in Great Falls.

Review comments from your office and the Department of Justice have been addressed in this final report. The report presents recommendations to reduce hazardous conditions at nine locations in the County. A recommended program for the continued evaluation of hazardous locations in the County is also presented.

We appreciate the opportunity to again be of service to the County and gratefully acknowledge the cooperation of your office and the Montana Department of Justice.

Sincerely,

HKM ASSOCIATES

James M. Fels, P.E.

JMF/cc

Enclosure

cc: A. T. Kersich  
Harry Lauer, w/o enc.  
Lou Fontana, w/o enc.



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TRAFFIC SAFETY STUDY  
FOR  
CASCADE COUNTY, MONTANA

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Condition/Accident Diagrams and Recommend Improvement  
Diagrams are arranged with Accident Summary Forms, Priority  
Index Determination Forms and site photographs for each  
location as follows:

- Evaluation and Recommendation Discussion
- Accident Summary Form
- Priority Index Determination Form (with sight distance)
- Site Photographs
- Condition Diagram
- Accident Diagram
- Recommended Improvement Diagram(s) (if applicable)

These figures are bound in the Section of this report  
titled "Evaluation and Recommendations by Location".

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## INTRODUCTION

The purpose of this study is to analyze several hazardous locations in Cascade County, to recommend improvements to increase safety at these locations, and to develop a systematic program for the future evaluation of hazardous locations in the County.

Fourteen locations were selected by the County for review in this study. After brief analysis of the number of accidents and accident locations, only nine sites were included for formal evaluation. The nine of the fifteen locations selected by the County, were analyzed using the preliminary evaluation program developed for DCA Project 79-04-01-01 without the volume/capacity ratio indicator value. This preliminary evaluation program is based on the methodology outlined in Report No. FHWA-RD-77-83 "Identification of Hazardous Locations".

This is the third formal study of hazardous locations in Cascade County. The first study was completed in 1980, and the second study in 1984. These ongoing studies provide a unique opportunity to test the conclusions reached in the earlier studies regarding the ongoing evaluation of hazardous locations in the County. As a result of the evaluation of the locations included in this project, the program recommended in the first study is reaffirmed with the exception that a benefit-cost analysis replaces the cost effectiveness evaluation to determine the priority ranking of long term improvements. The benefit-cost analysis is based on the methodology outlined for "On Federal Aid" system locations in the Montana Department of Highways Safety Engineering Improvement Program Manual.

This report presents the methodology used to evaluate the nine selected hazardous locations, the recommended evaluation program, and a discussion of the evaluation and recommendations for each of the locations studied. The recommended evaluation program is intended to provide a cost-effective method of continued identification and analysis of hazardous locations throughout the County road system.

## SUMMARY AND RECOMMENDATIONS

Based on the evaluation of the locations in Cascade County, a recommended program for evaluation of hazardous locations has been developed. It is recommended that locations in the County be evaluated for hazardousness using five parameters: Number of Accidents, Accident Rate, Accident Severity, Driver Expectancy, and Information System Deficiencies.

Two other parameters were considered for inclusion in this evaluation program: Volume/Capacity Ratio and Sight Distance. Since these parameters require considerable field work and/or



to be cost-effective for the ongoing County program. These parameters are, therefore, not included in the recommended evaluation program. The methodology used to develop the recommended evaluation program is similar to that used in the County's 1984 report. However, the sight distance parameter was included in the consultants analysis and its effect on the site ranking is shown in Table 5.

With the recommended evaluation program, a Hazard Index is developed for each location using Number of Accidents, Accident Rate, Accident Severity, Driver Expectancy, and Information System Deficiencies Indicators. A high Hazard Index indicates a relatively high degree of hazardousness is associated with that location. The recommended long term and/or short term treatment of each location is then determined. Short term improvements consist of signing or other relatively low cost treatments whereas long term improvements are generally higher cost treatments such as roadway reconstruction.

Short term improvements are implemented on the basis of a Short Term Priority Index which is identical to the Hazard Index. A priority list of the locations can be made by arranging the locations from highest to lowest Priority Index.

Long term improvements are prioritized for implementation by considering the costs and benefits of the improvements, as well as the Hazard Index. A Benefit-Cost Index Value is determined, which is a function of the cost of the recommended treatment for a location and of the potential benefit resulting from a reduction of accidents at that location. A weighted average of the Hazard Index and the Benefit-Cost Index is used to develop a Long Term Priority Index. A priority list of the locations can be made by again arranging the locations from highest to lowest Priority Index.

The nine locations selected for inclusion in this study, have been evaluated using the indicators of the recommended program and the sight distance parameter. The sight distance parameter was added since a transportation consultant visited each site and prepared the report. The site distance information was obtained in the field and used to broaden the Hazard Index Computation. Due to the rural nature of most of the sites studied, sight distance plays a more important role in the Hazard Index determination than volume/capacity. The effect on the Hazard Index with and without the sight distance indicator value can be seen in Table 5. For the County's ongoing evaluation, unless manpower proves available, the sight distance indicator value may be dropped from the computation of the Hazard Index and the relatively of the County's program will still be useful.

The results of this study's analysis are summarized in Table 1, Short Term Priority List; and in Table 2, Long Term Priority List. In both tables, the locations are listed in order of

priority using the Priority Index. The Hazard Index, Benefit-Cost Index (if applicable), the nature of the recommended treatment, the estimated cost of the improvements, and the benefit-cost ratio for each location are also shown. While the recommended evaluation program does not require the computation of a benefit-cost ratio for short term improvements, the benefit-cost ratio was computed for the sites in this study for informational purposes and is included in Table 1. A detailed evaluation of each location is presented later in this report. Accident summary sheets, priority index data sheets, site photographs, condition/accident diagrams, and recommended treatment diagrams (if applicable) are included for each location.

The Hazard Index and the Priority Index are not dependent on the number of locations studied. As additional locations are evaluated or existing locations are re-evaluated, the short term and long term priority lists can be adjusted according to the respective Priority Index.

County officials should make an annual review of accident records to identify hazardous "spot" locations for evaluation. These "spot" locations should consist of intersection locations, or non-intersection locations not exceeding 0.3 miles in length, unless specific conditions warrant the evaluation of a longer section as one location. An average of at least 1.0 accident or more per year over a three or four year period is recommended as the criteria to identify potentially hazardous locations. To ease County Officials in deciding what areas to evaluate, the County's program of plotting accident locations should be continued. However, to be meaningful, accident locations should be plotted on a large enough scale map so to allow the actual accident locations to be clear. The County may wish to plot each year's accidents on mylar so 3 or more years of data may be readily overlaid and accident trends studied.

The Montana Department of Justice can provide a printout of accidents by location. Approximately March 15th of each year the County should request a list of all accidents outside incorporated areas on roads within County responsibility, showing three or more accidents over the previous three years.

If the evaluation of a location indicates signing improvements may be warranted, care must be taken to assure that these improvements are designed and installed in conformance with the latest edition of the Manual on Uniform Traffic Control Devices (MUTCD).

Table 1

CASCADE COUNTY, MONTANA  
HIGH HAZARD LOCATION STUDY  
SHORT TERM PRIORITY LIST  
(includes Sight Distance Parameter)

Priority	Location No. and Description	Priority Index	Hazard Index	Recommended Treatment	Estimated Cost (\$)	Eligible For FHWA Funding (\$)	Benefit-Cost Ratio
1	3-Gibson Flats Rd & 26th St. S. T20N R4E Section 19/20	58.97	58.97	Signing, Striping & Pavement Removal	2,570	990	4.32
2	15 Fox Farm Rd and 45th Ave. SW T20N R3E Section 22/23	53.00	53.00	Signing & Delineation	2,420	1,840	5.55
3	4-Lower River Rd. and Trailer Terrace T20N R3E Section 36	52.20	52.20	Signing, Striping & Delineation	9,920	1,730	1.08
4	2-McIver Rd. west of Manchester Rd. T20N R2E Section 2	49.45	49.45	Signing & Delineation	8,610	730	0.72
5	1-Giant Springs Rd. T21N R4E Section 34	44.76	44.76	Signing & Guardrail	15,120	14,320	0.96
6	8-24th Ave. S. and 13th St. S. T20N R4E Section 18	35.29	35.29	Signing & Striping	3,350	660	0.45
7	14-18th Ave. SW and 14th St. SW T20N R3E Section 15	33.24	33.24	Signing, Delineation, & Striping	3,190	990	0.61
8	11-Smelter Ave. and 10th St. S. T20N R3E Section 1	29.81	29.81	Signing, Lighting, & Striping	11,460	920	1.54
9	5-2nd Ave. N. from 57th to 60th Street T20N R4E Section 10	24.98	24.98	Signing & Signal Heads	6,500	300	1.96



Table 2

CASCADE COUNTY, MONTANA  
HIGH HAZARD LOCATION STUDY  
LONG TERM PRIORITY LIST  
(Includes Sight Distance Parameter)

Priority	Location No. and Description	Priority Index	Hazard Index	Benefit-Cost Index	Recommended Treatment	Estimated Cost (\$)	Eligible For FHWA Funding (\$)	Benefit-Cost Ratio
1	15 Fox Farm Rd and 45th St. SW T20N R3E Section 22/23	48.75	53.00	36	None	-----	-----	-----
2	3-Gibson Flats Rd and 26th St. S. T20N R4E Section 19/20	44.23	58.97	0	Signing & Improve Sight Distance	52,940	480	0.27
3	4-Lower River Rd and Trailer Terrace T20N R3E Section 36	39.15	52.20	0	Minor Reconstruction/ Pavement Removal	9,150	140	0.38
4	2-McIver Rd west of Manchester Road T20N R2E Section 2	37.09	49.45	0	None	-----	-----	-----
5	1-Giant Springs Road T21N R4E Section 34	33.57	44.76	0	None	-----	-----	-----
6	8-24th Ave. S. and 13th St. S. T20N R4E Section 18	26.47	35.29	0	None	-----	-----	-----
7	14-18th Ave. SW and 14th St. SW T20N R3E Section 15	24.93	33.24	0	Curb, Gutter & Sidewalk	37,100	1,210	0.01
8	11-Smelter Ave. and 10th St. N. T20N R3E Section 1	22.36	29.81		Lighting, Signals & New Turn Lane	72,680	280	0.17
9	5-2nd Ave. N. and (57th to 60th St.) T20N R4E Section 10	18.74	24.98	0	Reconstruction & New Signals	103,600	760	0.12

All locations where improvements are made should be monitored. The effectiveness of the improvements made at a particular location should be checked by re-evaluation of the Hazard Index for that location three to four years after the improvements are completed. Locations one and five of this study have been evaluated in the County's previous studies.

The effectiveness of an evaluation program for identification of hazardous locations is dependent on the data used in the evaluation. Good accident records must be maintained to identify potentially hazardous locations. The County's system of route numbers and mile posts should be used in accident reporting to help assure that proper records are maintained in usable form. Accident plots should carry some form of identifying code or number correlating it to the actual accident report for ease of analysis. Locations with many reported accidents may be plotted once, and noted to the side.

Traffic volume data is equally important for the evaluation of hazardousness. It is essential that County officials continue and maintain the ongoing County wide traffic count program. This should include and expand on the efforts of the City-County Planning Board and the Montana Department of Highways. The traffic count program should, at a minimum, cover all the urbanized areas of the County once every three years. Other locations in the County should be counted if they appear to be hazardous. Hourly variation information at the locations counted should be retained at least until counts are updated.

#### EVALUATION METHODOLOGY

This section of the report outlines the methodology used to analyze the selected locations. Site numbers are not in order reflecting those sites which were not included in full evaluation. The following nine locations were selected by the County for full evaluation:

1. Giant Springs Road (Rainbow Dam Area)
2. McIver Ranch Area, west of Manchester Lane
3. Gibson Flats Rd. and 26th St. S
4. Lower River Rd. and Trailer Terrace/55th Ave. S.
5. 2nd Avenue North from 57th to 60th Streets.
8. 24th Avenue S. and 13th St. S.
11. Smelter Avenue and 10th St. N.

14. 18th Ave. SW and 14th St. SW

15. Fox Farm Rd. and 45th Ave. SW

These locations are identified on Figure 1 found in the pouch at the end of this study.

#### Data Collection

The initial step in this study was to collect the data required for the evaluation of the locations. This data includes accident records, traffic data, and information regarding the physical layout of each location. A three year study period was used as the basis for the evaluations. This period covered January 1986 through December 1988.

Copies of accident reports for the study period were furnished by the Montana Department of Justice through Cascade County. These accident reports were obtained from State microfilm records in Helena.

No available aerial photography was furnished for use in this study. Current (1988 or 1989) traffic volume data at the locations to be studied was available for six of the sites. Since information regarding the physical layout of all locations was very limited, it was necessary to collect this data through field surveys. Hourly turning movement or line counts were collected at all but Sites 1 and 5 since data was in a usable format there. Traffic was counted for one-hour periods during September 1989 and then expanded into average daily traffic volumes at the counted locations. This was accomplished using hourly and monthly adjustment factors. A monthly adjustment factor of 0.93 was used for rural sites and 0.92 was used for urban sites, based on information obtained from the Montana Department of Highways Planning and Statistics Bureau. Information regarding hourly fluctuations of traffic was available for Cascade County from the City of Great Falls. A chart showing representative Cascade County hourly variations in traffic volume is shown on Figure 2. Monthly correction factors are listed in Table 3 for both rural and urban sites. Manual traffic counts and average daily traffic volumes for each location are shown in Table 4.

Once all of the required data was collected, condition/accident diagrams were prepared for each of the nine locations.

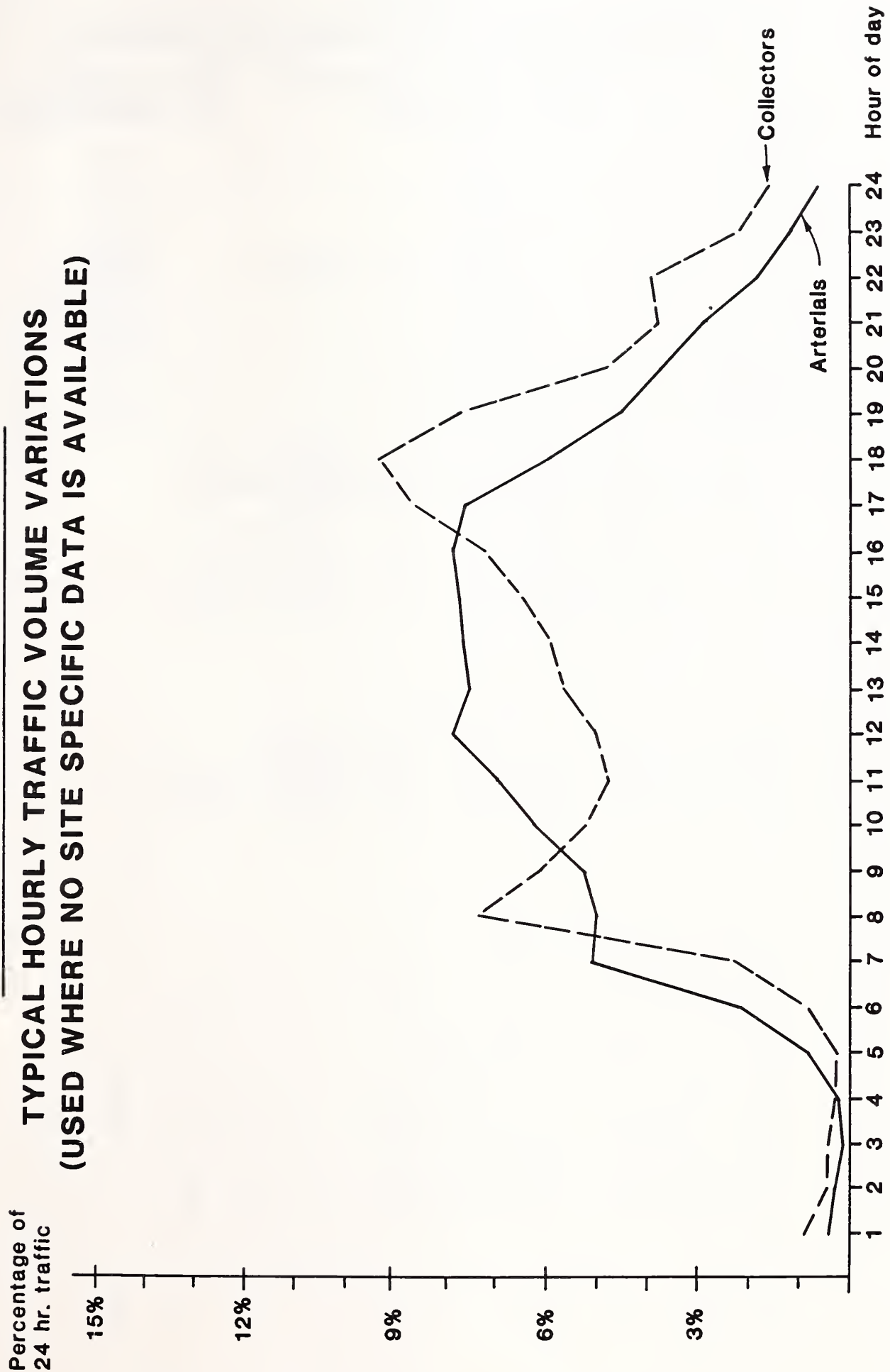
#### Preliminary Evaluation

Each location was evaluated for hazardousness using the preliminary evaluation program developed for DCA Project 79-04-01-01 (HKM Associates, January 1979, Preliminary

Evaluation Program for High Hazard Location Study, Yellowstone County, Montana) except the volume/capacity indicator was omitted. This preliminary evaluation program is based on the methodology outlined in Report No. FHWA-RD-77-83 "Identification of Hazardous Locations".

# GREAT FALLS METRO AREA

TYPICAL HOURLY TRAFFIC VOLUME VARIATIONS  
(USED WHERE NO SITE SPECIFIC DATA IS AVAILABLE)



Source: Cascade Clity County Planning

FIGURE 2

Table 3  
MONTHLY TRAFFIC VOLUME CORRECTION FACTORS

<u>Month</u>	<u>Correction Factor for Rural Sites</u>	<u>Correction Factor for Urban Sites</u>
January	1.06	1.03
February	1.03	1.01
March	0.95	0.94
April	0.91	0.92
May	0.88	0.89
June	0.86	0.85
July	0.89	0.86
August	0.90	0.88
September	0.93	0.92
October	0.94	0.91
November	0.98	0.96
December	0.99	0.94

Source: Montana Department of Highways, 1988.



Table 4  
TRAFFIC SAFETY STUDY OF  
ACCIDENT LOCATIONS IN  
CASCADE COUNTY

Manual Traffic Counts and Average Daily Traffic Volumes

<u>Site</u>	<u>Location</u>	<u>Date</u>	<u>Time</u>	Total Vehicles Entering Field Count (Vehicles)	Total Vehicles Enter ADT
1	Giant Springs Road	1989 1987	24 hour machine 24 hour machine	----- -----	753 570
2	McIver Road	9/15/89 9/21/89 9/22/89 9/25/89	8:00-9:00 AM 24 hour machine 24 hour machine 24 hour machine	26 392 404 382	396 365 375 355
3	Gibson Flats & 26th St. S.	9/12/89	3:30-4:30 PM	105	1,235
4	Lower River Road & Trailer Terrace	9/14/89	8:00-9:00 AM	109	1,659
5	2nd Ave. N. & 57th - 60th Streets	1988 1989	24 hour machine Extrapolation from historical data	----- -----	12,665 13,000
8	13th St. S. & 24th Ave. S.	9/12/89	9:00-10:00 AM	130	2,325
11	Smelter Ave. & 10th St. N.	9/13/89	8:00-9:00 AM	1,087	18,282
14	18th Ave. SW & 14th St. SW	9/14/89	3:00-4:00 PM	125	1,610
15	Fox Farm Rd & 45th Ave. S.	9/14/89	1:00-2:00 PM	91	1,223

The preliminary evaluation program utilizes seven parameters or indicators to determine the degree of hazardousness of a location. These are:

1. Number of Accidents,
2. Accident Rate,
3. Accident Severity,
4. Volume/Capacity Ratio, (omitted for this study)
5. Sight Distance,
6. Driver Expectancy, and
7. Information System Deficiencies.

Each of these indicators is a measure of some aspect of the hazardousness of a particular location. Using the preliminary evaluation program, an Indicator Value was developed for each of the above parameters. Since some of the indicators are stronger than others, the individual indicator values are weighted according to their ability to predict future accident experience. These weighted indicator values are then combined to determine a Hazard Index for each location. The Hazard Index values range from 0 to 100 with the larger values indicating a higher degree of hazardousness.

Indicators 1, 2, and 3 are "accident" indicators. Indicator values are obtained utilizing accident statistics and traffic volumes. Accident records covering three or more years for a particular location should be used. For a non-intersection location a "spot" length of 0.3 miles should be used unless individual conditions warrant otherwise. It should be noted that several of the locations selected by the County exceed 0.3 miles in length. Indicators 4 through 7 are "non-accident" indicators. Indicator values are based totally on non-accident measures such as the roadway environment and geometry.

The data initially collected were used to develop indicator values for Indicators 1 through 5. To determine indicator values for the Driver Expectancy and Information System Deficiencies indicators, it was necessary to rate each location using guidelines defined in the preliminary evaluation program. Each location was visited and rated by a two member team. The team was comprised of non-technical people because the ratings are intended to reflect an average driver's perception of these parameters.

After the Hazard Index values were determined, each location was studied to determine what improvements should be made to reduce the hazardousness of that site. Existing signing was reviewed for conformance with the Manual on Uniform Traffic Control Devices (MUTCD). The safe driving speed of horizontal curves was determined using a ball bank indicator. Where road conditions warranted verification of the ball bank indicator, the safe driving speed was computed using the following relationship for comparison:



$V = [15 r (e + f)]^{1/2}$ ; where  
V is the safe driving speed in MPH,  
r is the radius of the curve in feet,  
e is the rate of superelevation in ft/ft, and  
f is the coefficient of side friction.

For the speeds and conditions at the locations studied, a value of  $f = 0.15$  was generally used in this equation. However, values of 'f' may vary depending on the specific conditions at a location.

At locations where either horizontal or vertical sight distance appeared to be limited, the actual sight distance was determined and compared with safe stopping sight distances presented in the AASHTO "Green Book" (American Association of State Highway Officials, 1985, A Policy on Geometric Design of Highways and Street). Other elements of specific locations which were also evaluated to develop recommendations for improvements include accident occurrence, traffic volumes and speeds, and the existing geometrics of the location.

Recommended improvements were divided into two categories; short term improvements and long term improvements. Short term improvements generally consisted of signing or other low cost improvements which could be implemented easily to improve the safety at a particular location. At some locations, additional and more costly improvements were felt to be warranted such as reconstruction of a section of roadway. These improvements were identified as long term improvements which could then be programmed by the County for construction as funding becomes available. Preliminary cost estimates were developed for the improvements at each location based on approved Federal Highway Administration (FHWA) improvement costs. Where recommendations were made for other than approved FHWA improvements, 1989 statewide average bid prices for similar improvements furnished by the Montana Department of Highways were used.

The next step in the evaluation of the hazardous locations was to develop a Priority Index for each location. A priority list can then be prepared by ranking the locations from highest Priority Index to lowest Priority Index.

For short term improvements the Priority Index is identical to the Hazard Index. Since the cost of short term improvements is relatively small, it is felt that the most hazardous locations should be upgraded first.

For long term improvements the Priority Index is a weighted average of the Hazard Index and a Benefit-Cost Index. A twenty year period was selected as a reasonable design life for the recommended long range improvements. To obtain future traffic volumes, the current volumes were increased by an annual growth factor of 3% per year. This growth factor appears to correlate

with traffic projections developed by the Montana Department of Highways Planning and Statistics Bureau for the Great Falls area.

A Benefit-Cost ratio was determined for the long range as well as the short term improvements using the methodology for "On Federal Aid" system roads as outlined in the Montana Department of Highways Safety Engineering Improvement Program manual. The "on system" methodology was mandated because of recent changes in legislation that allow MDOH to use federal aid secondary funds for certain off system safety projects. The use of this methodology will permit the Department of Highways to compare these "off system" projects with other "on system" projects.

The Long Term Priority Index is a weighted average of the Hazard Index and the Benefit-Cost Index. For this study the Hazard Index was weighted 0.75 and the Benefit-Cost Index was weighted 0.25. These weighting factors are based on the sum of the applicable weights found in the Report FHWA-RD-77-83 for those indicators used in the Cascade County recommended program.

#### Modifications to Preliminary Evaluation Program

After completion of the initial evaluation of the nine locations, possible modifications to the evaluation program were studied. To establish the merit of deleting the sight distance indicator, a new Hazard Index was determined for each location eliminating this parameter. The results of this analysis are shown on Table 5.

While elimination of indicator number 4 did result in changes in the relative ranking of locations, the changes in most cases did not appear to be significant. Therefore, no additional analyses were performed. A Hazard Index was again computed for each location both with and without the Sight Distance Indicator Value Number 4.

Since a considerable amount of time and data are required to develop Indicator Values for the volume/capacity and sight distance parameters, and since the required calculations are somewhat technical in nature, it is felt that the Volume/Capacity Ratio and Sight Distance indicators are not cost-effective for continuing use in the Cascade County program. The recommended evaluation program, therefore, does not include these indicators. This study does include the sight distance indicator since consultant manpower was available. Table 6 shows the complete H.I. computations.

TRAFFIC SAFETY STUDY  
ACCIDENT LOCATIONS IN  
CASCADE COUNTY

Table 5  
Hazard Index Sensitivity

<u>SITE NO.</u>	<u>LOCATION</u>	<u>HAZARD INDEX</u>	<u>Rank WITH Sight Distance IV'S</u>	<u>HAZARD INDEX</u>	<u>Rank WITHOUT Sight Distance IV'S</u>
1	Giant Springs Rd.	44.76	5	47.54	4
2	McIver Rd. (W. of Manchester Ln)	49.45	4	45.44	5
3	Gibson Flats Rd. & 26th St. S.	58.97	1	58.61	1
4	Lower River Rd. & Trailer Terrance	52.20	3	54.74	2
5	2nd Ave. N (57th to 60th St.)	24.98	9	25.14	9
8	24th Ave. S. & 13th St. S.	35.29	6	38.28	6
11	Smelter Ave. & 10th St. S.	29.81	8	32.48	7
14	18th Ave. SW & 14th St. SW	33.24	7	31.51	8
15	Fox Farm Rd. & 45th Ave. SW	53.00	2	49.77	3

Hazard Index Analysis  
WITH Sight Distance  
Indicator Value

[illegible][illegible]





## RECOMMENDED EVALUATION PROGRAM

The recommended program for evaluation of hazardous locations in Cascade County, Montana, is presented in this section of the report. This program will enable the County to identify and prioritize hazardous locations using a systematic and cost effective approach. Report No. FHWA-RD-77-83 "Identification of Hazardous Locations" was used in the development of this program.

With this program, a Hazard Index is first determined for each location to be studied. Consideration is then given to improvements to reduce the hazardousness of each location. Improvements are categorized as short term or long term and the locations are then prioritized for implementation of the improvements using a Priority Index.

Short term improvements generally consist of relatively low cost improvements such as signing or delineation which can be implemented easily to improve the safety at a particular location. At some locations, additional and more costly improvements, such as reconstruction of a section of roadway, may be warranted. These would be considered as long term improvements.

The Priority Index for short term improvements is identical to the Hazard Index. Due to the relatively low cost nature of the improvements, the more hazardous locations receive higher priority. For long term improvements consideration is given to the potential benefit from a reduction of accidents resulting from the improvements at each location using a Benefit-Cost Indicator. The Benefit-Cost Indicator attempts to adjust the priority of each location utilizing this benefit-cost concept.

### Hazard Index (H.I.)

The Hazard Index is developed using the following six parameters or indicators:

1. Number of Accidents
2. Accident Rate
3. Accident Severity
4. Sight Distance
5. Driver Expectancy
6. Information System Deficiencies.

Each of these indicators is a measure of some aspect of hazardousness of a particular location. The raw data for each of these indicators must be converted to an Indicator Value for use in the Hazard Index Formula. This is accomplished by the use of charts developed for that purpose. These charts are presented later in this section of the report. Indicator

Values range from 0 to 100. Larger values indicate higher degrees of hazardousness. Four control values are used in establishing the charts as follows:

1. An indicator value of 0 indicates there is no contribution to hazardousness from a particular source.
2. An indicator value of 33 is the value used to separate hazardous sites from "normal" sites.
3. An indicator value of 67 or above indicates a very hazardous site.
4. An indicator value of 100 is the highest value possible.

Some indicators are stronger than others, of course, and the individual Indicator Values are, therefore, weighted according to their ability to predict future accident experience. Since the sum of the weighting factors is 1.00, the Hazard Index will also have a value of from 0 to 100. Again a larger Hazard Index Value indicates a more hazardous location.

For this study the Hazard Index is developed using the following relationship:

$$\begin{aligned} \text{H.I.} = & 0.178 \text{ (I.V.) Number of Accidents} \\ & + 0.245 \text{ (I.V.) Accident Rate} \\ & + 0.208 \text{ (I.V.) Accident Severity} \\ & + 0.081 \text{ (I.V.) Sight Distance} \\ & + 0.162 \text{ (I.V.) Driver Expectancy} \\ & + 0.125 \text{ (I.V.) Information System Deficiencies} \end{aligned}$$

For the continuing Cascade County evaluation program the Hazard Index would be computed as follows:

$$\begin{aligned} \text{H.I.} = & 0.194 \text{ (I.V.) Number of Accidents} \\ & + 0.266 \text{ (I.V.) Accident Rate} \\ & + 0.226 \text{ (I.V.) Accident Severity} \\ & + 0.177 \text{ (I.V.) Driver Expectancy} \\ & + 0.137 \text{ (I.V.) Information System Deficiencies} \end{aligned}$$

Indicator 1: Number of Accidents. A primary strength of this indicator is that data are continuously collected through accident reporting procedures and are easily accessible. Unfortunately, the use of past accident experience to predict future experience is limited by the randomness in accident occurrence, particularly at sites with a low or medium number of accidents per year.

The data value used to arrive at an Indicator Value is the average number of accidents per year using data from a three year period for a particular location. For a non-intersection



location, a "spot" length of 0.3 miles should be used unless individual conditions warrant otherwise.

The control values for this indicator are as follows:

Indicator Value of 0	0	ACC/YR
Indicator Value of 33	1.5	ACC/YR
Indicator Value of 67	7.0	ACC/YR
Indicator Value of 100	30.0	ACC/YR

These data values were selected to be responsive to local conditions. Figure 3 shows the relationship between Number of Accidents per Year and Indicator Value.

Indicator 2: Accident Rate. This indicator is one of the most accepted factors in determining the hazardousness of a particular location because it combines numbers of accidents with traffic volumes. The use of the Accident Rate indicator alone, however, can be misleading. For example, a few accidents on a low volume road will result in a very high accident rate and will give too much emphasis to this location when compared to a high volume intersection with a high number of accidents producing a low accident rate.

The inclusion of both accident number and accident rate indicators in the Hazard Index Formula tends to offset the major deficiency in each so that high volume locations can be compared on an equal basis with low volume locations.

The data value used to arrive at an Indicator Value is the number of accidents per million vehicles entering a location per year. Again a three year period should be used to account for the random occurrence of accidents. The accident rate can then be determined by dividing the number of accidents by the sum of the approach volumes.

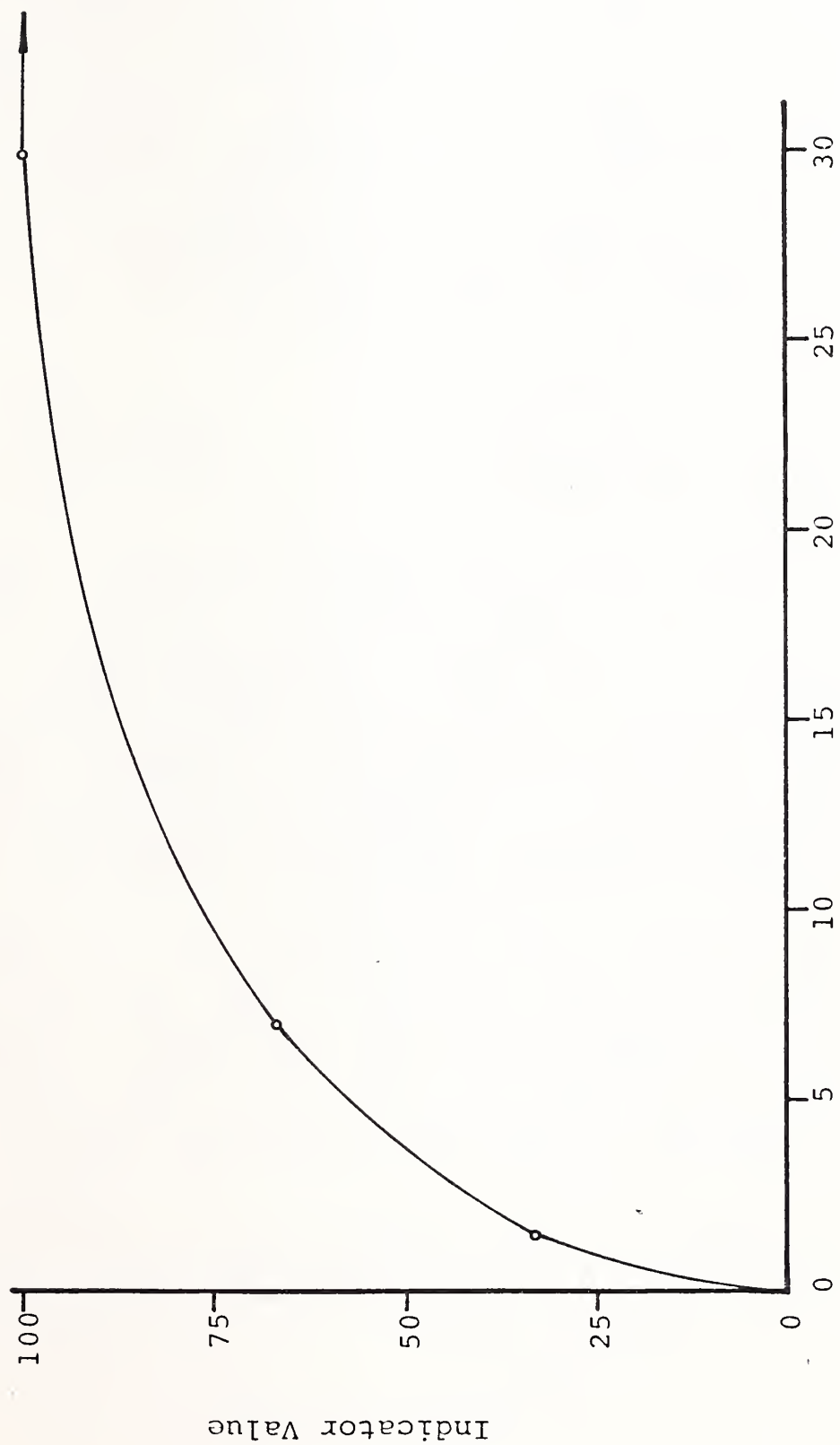
Control values for the Accident Rate Indicator are as follows:

Indicator Value of 0	0	ACC/MEV
Indicator Value of 33	2	ACC/MEV
Indicator Value of 67	5	ACC/MEV
Indicator Value of 100	10	ACC/MEV

These control values were again selected to reflect local conditions. Figure 4 shows the relationship between ACC/MEV and Indicator Value.

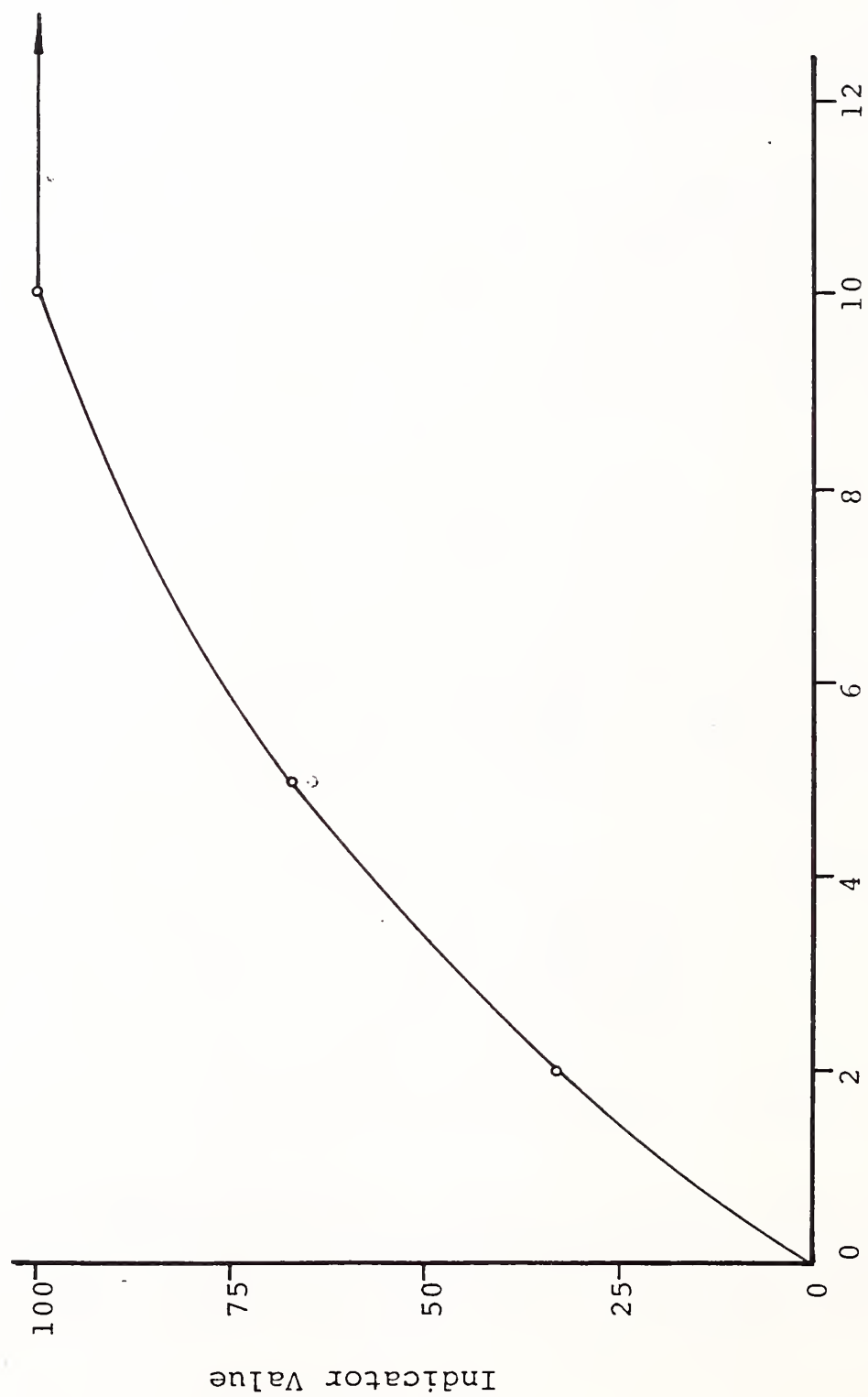
Indicator 3: Accident Severity. This indicator provides a means of identifying the hazardousness of a location based on the severity of accidents at that location. If two locations have approximately equal accident rates, a difference in severity will be a strong indicator of which location is the more hazardous.





No. of Accidents per Year (3 year average)

Figure 3 Indicator Values for Number of Accidents.



Accidents per Million Entering Vehicles (3 year average)

Figure 4 Indicator values for Accident Rate.

The data input for this indicator is the average "Relative Severity Index" (RSI). Again accidents over a three year period should be used to determine the average RSI. The FHWA report recommends using RSI values as shown in Table 7. It should be noted that the RSI values listed in this Table are not necessarily economic losses to society, but a proxy measure of losses in societal welfare. It should also be noted that the RSI value for a particular location is not directly dependent on whether an accident is a personal injury accident or involves a fatality. The average number of fatalities, injuries, and property damage for all accidents within a category were taken into consideration when the RSI values were developed. In this manner, a random accident involving a fatality is not overemphasized. The average RSI is determined by summing the RSI for each accident over the three year period and dividing this total by the number of accidents over the period.

Indicator Value of 0	avg RSI of \$ 0
Indicator Value of 33	avg RSI of \$ 2,000
Indicator Value of 67	avg RSI of \$ 13,000
Indicator Value of 100	avg RSI of \$ 30,000

It is recommended these control values be used in the Cascade County program. Figure 5 shows the relationship between average Relative Severity Index and Indicator Value.

Indicator 5: Driver Expectancy. Drive expectancy relates to the readiness of the driver to respond to events, situations, or the presentation of information. It is a totally subjective parameter which attempts to deal with the drivers experience rather than an event on the roadway. For example, horizontal curves immediately beyond the crest of vertical curves, or stop signs around horizontal curves are locations where driver expectancy contributes to the hazardousness of a location.

The data input for this indicator is a Driver Expectancy Problems Rating for each approach to the site under consideration. A form for use in determining this rating is shown on Figure 6. Using this form, each approach to the site would be rated on a scale from 0 (excellent) through 6 (critical). Each site should be visited by one or more individuals, and the average of the values assigned to each approach by each individual is used as the approach rating.

The Indicator Values for Driver Expectancy are determined from a linear scale using the rating limits indicated above as control values. In other words the control values are:

Indicator Value of 0	Driver Expectancy Problems Rating of 0
Indicator Value of 100	Driver Expectancy Problems Rating of 6

Table 7  
RELATIVE SEVERITY INDEX

<u>Type of Accident</u>	<u>RSI</u>	
<u>Multi-Vehicle, At Intersection</u>	<u>Urban</u>	<u>Rural</u>
Entering at angle	\$ 4,300	\$14,400
From same direction-both going straight	2,800	5,100
From same direction-one turn, one straight	2,500	5,100
From same direction-one stopped	3,800	5,200
From same direction-all others	2,000	6,300
From opposite direction-both going straight	4,000	20,000
From opposite direction-one left turn, one straight	4,400	15,400
From opposite direction-all others	2,700	3,800
Not stated	3,800	5,200
<u>Multi-Vehicle, Non-Intersection</u>		
Going opposite direction-both moving	\$ 4,400	\$19,600
Going same direction-both moving	2,900	8,100
One car parked	1,600	2,400
One car stopped in traffic	4,200	6,800
One car entering parked position	1,900	2,300
One car leaving parked position	1,200	2,700
One car entering alley or driveway	3,400	6,000
One car leaving alley or driveway	2,000	4,400
All others	1,700	7,600
Not stated	3,400	6,000
<u>Motor Vehicle with Pedestrian, at Intersection and Non-Intersection</u>		
Vehicle going straight	\$20,000	\$49,000
Vehicle turning right	13,600	11,200
Vehicle turning left	17,100	11,200
Vehicle backing	20,600	11,200
All others	14,500	11,200
Not stated	11,200	11,200
<u>Single Vehicle, at Intersection</u>		
Collision with train	\$26,700	\$39,100
Collision with bicycle	13,100	31,900
Injury in vehicle, jackknifed	5,200	2,000
Collision with fixed object in road	5,500	7,000
Overtuned in road	9,200	7,500
Left road	5,200	12,300

Continued

Table 7  
(Continued)

<u>Type of Accident</u>	<u>RSI</u>	
<u>Single-Vehicle, Non-Intersection</u>	<u>Urban</u>	<u>Rural</u>
Collision with train	\$26,700	\$39,100
Collision with bicycle	13,100	31,900
Injury in vehicle, jackknifed	5,200	2,000
Collision with fixed object in road	6,300	9,200
Overtuned in road	10,000	9,400
Left road at curve	7,600	12,400
Left road on straight road	5,200	10,500
<u>Other One Motor Vehicle, At Intersection and Non-Intersection</u>		
Fell from moving vehicle	\$15,000	\$57,200
Collision with animal	4,800	1,800
Collision with other object	4,700	4,400
All others	5,200	2,000
Not stated	3,200	3,400

Source: Report No. FHWA-RD-77-83  
"Identification of Hazardous Locations"

Figure 7 shows the relationship between Driver Expectancy Problems Rating and Indicator Value. An Indicator Value is determined for each approach to a particular location. Then the weighted average of the two highest Indicator Values is determined and this value is used as the Indicator Value for that location. The highest Indicator Value is weighted 2.0 and the next highest Value is weighted 1.0

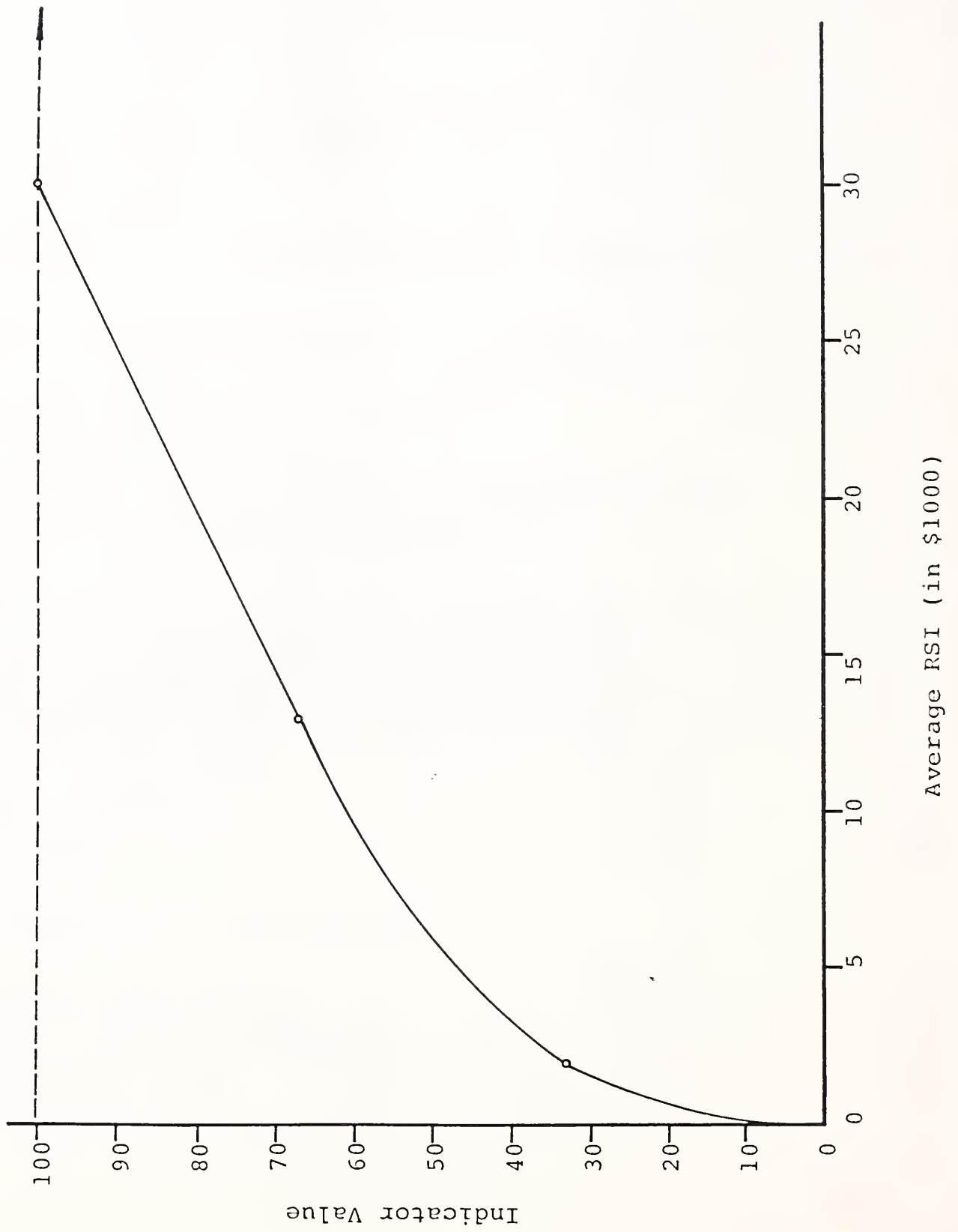


Figure 5 Indicator value for accident severity.



# DRIVER EXPECTANCY PROBLEMS RATING FORM

## Ratings:

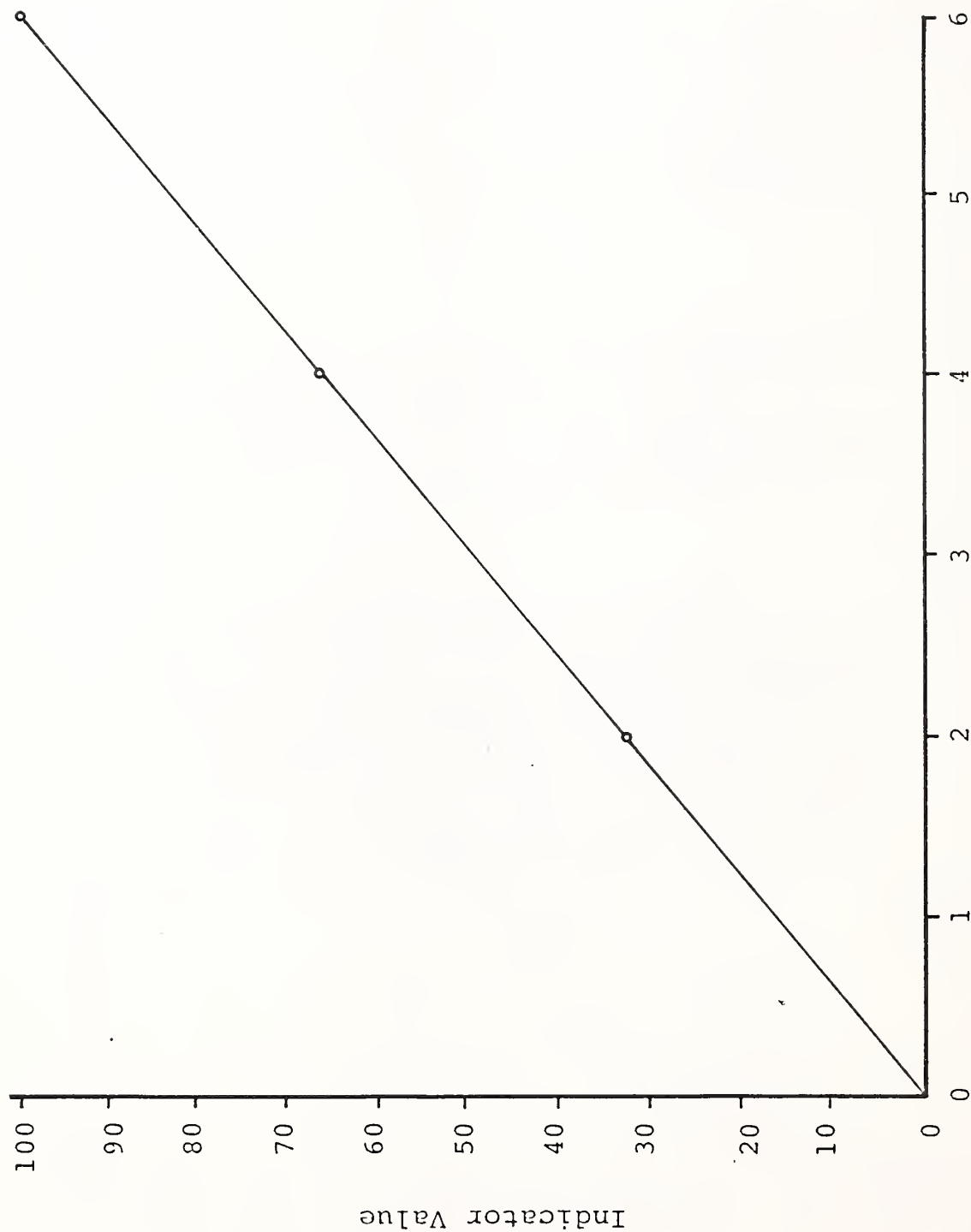
- 0 -- Nothing unexpected or unusual at this location.  
 Actions required (if any) entirely consistent with driving strategy on approach.  
 Standard geometry, with pathway(s) for intended movement(s) clearly evident.  
 No interferences by other traffic likely.
- 1 --
- 2 --
- 3 -- Situation somewhat unexpected.  
 Driver must be alert, but should be able to respond adequately at "last minute" to most combinations of adverse circumstances.  
 Some initial confusion on intended path(s) or movement(s).  
 Interference from other traffic may create some degree of confusion or uncertainty for average driver.
- 4 --
- 5 --
- 6 -- Very unusual situation; will "surprise" many unfamiliar drivers.  
 Driver required to make major change in driving tactics from those employed over past few miles.  
 At least a "near accident" almost expected if driver is even moderately inattentive; evasive actions likely to be required.  
 Intended pathway(s) confusing under fairly normal traffic or lighting conditions.  
 Other traffic, or lack of it, aggravates situation and misleads driver or deprives him of important cues.

## Approach

## Rating

	0	1	2	3	4	5	6
A							
B							
C							
D							

Figure 6 'Driver expectancy problems rating form.



Driver Expectancy Problems Rating

Figure 7 Indicator values for driver expectancy.



Indicator 6: Information System Deficiencies. This is a subjective indicator of the adequacy of the systems at a location to enable the driver to make correct judgments and decisions. An inadequate information system creates a hazardous situation.

The data input for this indicator is an Information System Deficiencies Rating for each approach to the site under consideration. A form for use in determining this rating is shown on Figure 8. As with the Driver Expectancy Problems Rating, each approach must be rated by one or more individuals and the average of these ratings will be used as the approach rating. The Information System Deficiencies Rating form provides for rating each approach on a scale from 0 (excellent) through 6 (critical).

The Indicator Values for Information System Deficiencies are again determined from a linear scale using the above limits as control values. Figure 9 shows the relationship between Information System Deficiencies Rating and Indicator Value. An Indicator Value is determined for each approach and the weighted average of the two highest values is used as the Indicator Value for that location again using weighting factors of 2.0 and 1.0 respectively.

#### Priority Index

Once a Hazard Index has been determined for a location, an evaluation must be made to develop the recommended treatment for that location together with preliminary cost estimates. Improvements should be divided into two categories; short term improvements and long term improvements.

Short term improvements generally consist of signing or other relatively low cost improvements which can be implemented easily. Long term improvements generally involve more costly treatments such as reconstruction of a section of roadway. Based on the type of improvements recommended, a Priority Index is determined for each location as discussed below.

Short Term Priority Index (S.P.I.). The Priority Index for short term improvements is identical to the Hazard Index. Due to the relatively low cost nature of these improvements the most hazardous locations should be given highest priority for treatment.

Long Term Priority Index (L.P.I.). The Priority Index for long term improvements gives consideration to the cost and potential benefit from accident reduction resulting from the improvements at each location using a Benefit-Cost Indicator. To determine a Benefit-Cost Index Value for a particular location, a cost estimate for the long term improvements must be prepared and the projected benefits must be computed. A twenty year period is recommended as a reasonable design life for roadway reconstruction or other long term projects.

# INFORMATION SYSTEM DEFICIENCIES RATING FORM

## Ratings:

- 0 -- Information for required decisions complete and unambiguous.  
Signs, markings, delineation in good repair, clean, highly visible.  
"Positive guidance" leads driver to appropriate path; makes "error" difficult.  
Approach speeds of most drivers are appropriate.  
Light decision load; easy and obvious.
- 1 --
- 2 --
- 3 -- Some information lacking or somewhat misleading.  
Signs should be moved or augmented for better visibility or to provide more decision time.  
Visibility of signs, markings, and delineation barely adequate.  
Advisory speed information should be changed slightly, or added.  
Medium decision load; average driver will be able to handle situation, but may be a little uncomfortable.
- 4 --
- 5 --
- 6 -- Important information missing.  
Complete new "information system" needed -- design and installation.  
Present signs and markings in very poor condition; need replacement.  
Speed limit and/or advisory speed needed; either missing or totally inappropriate at present.  
"Positive guidance" on appropriate path lacking; a clutter of negative delineation only.  
Heavy decision load; complete attention of average driver required; a "tense" situation at best.

<u>Approach</u>	<u>Rating</u>						
	0	1	2	3	4	5	6
A							
B							
C							
D							

Figure 8 Information system deficiencies rating form.

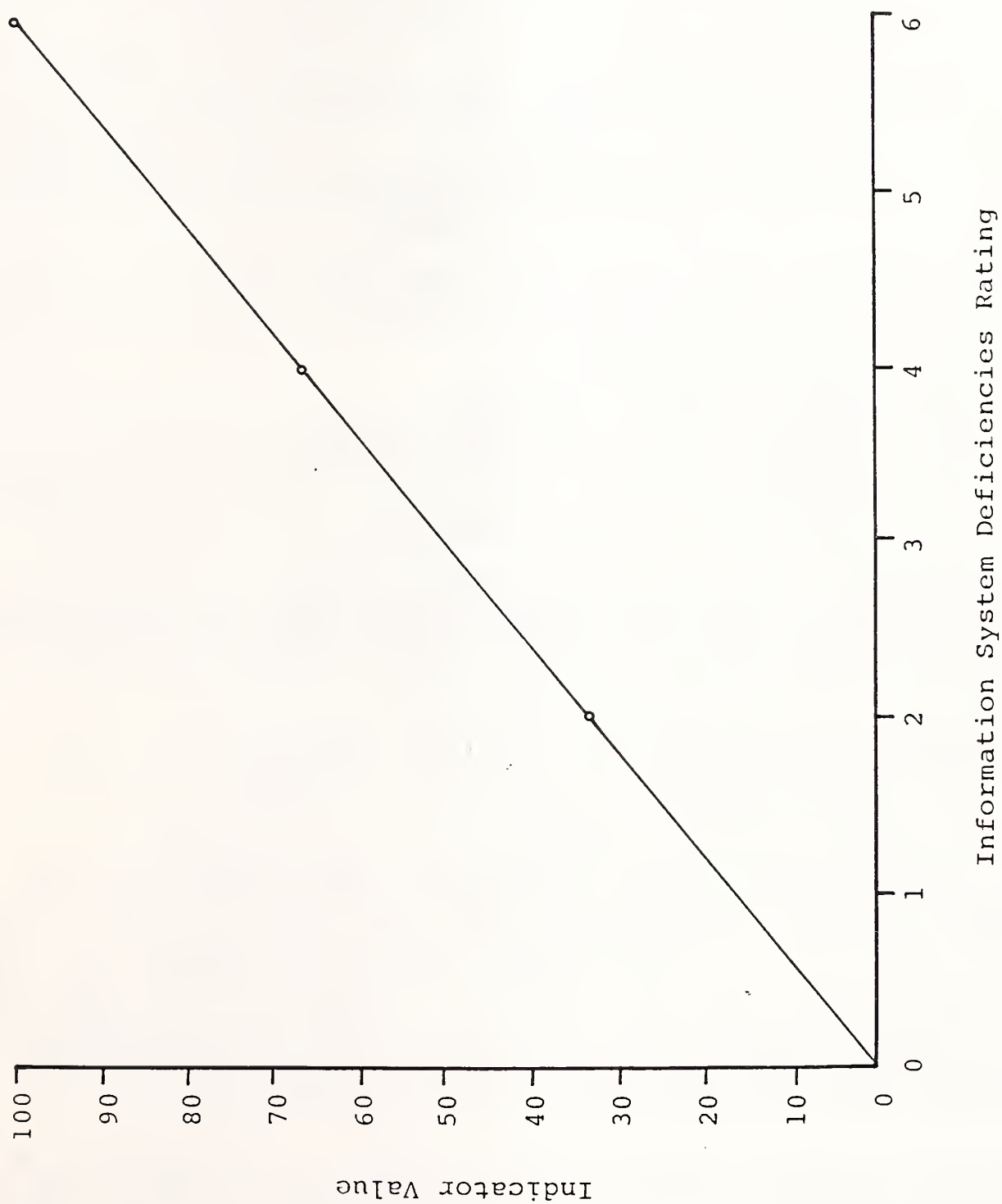


Figure 9 Indicator values for information system deficiencies.

The methodology for determining the benefit-cost ratio is based on the procedure outlined in the Montana Department of Highways Safety Engineering Improvement Program manual for "On Federal Aid" system roadways. The following description of the benefit-cost computation procedure is taken from the above referenced manual.

The planned benefit concept, in general, is that:

1. the total economic loss as a result of traffic accidents at a specific location is determined by multiplying the cost per accident by the number of accidents, and
2. that specific objectives for reduction of actual accident experiences are being set and are measurable.  
For example: Objective - to reduce the number of accidents at a location by 16 percent (from 25 to 21 accidents) during the first year after the improvement at the location has been made.

With the above concept in mind, the total benefits (in dollars) is the sum of the value of the reduction in each benefit unit. The benefit units may include:

- 1) Accidents reduced,
- 2) Fatal accidents reduced,
- 3) Injury accidents reduced,
- 4) Property damage accidents reduced,
- 5) Combinations of the above as selected and documented.  
(One may select combinations in order to avoid over weighting of certain factors)

In general, the costs per accident which are used are those derived by the National Safety Council and published annually in their Memo Number 113. This memo is updated and distributed in July of each year.

The unit costs assigned for 1988 are:

per fatal accident	=	\$500,000
per injury accident	=	11,000
per property damage accident	=	1,500

In the Montana Safety Engineering Improvement Program, the fatal and injury accidents benefits calculation are combined into a single quotient called "Q". "Q" is used because fatality figures are relatively small and a matter of chance. The State of Montana prefers to combine fatal and injury accident totals to play down the possibility of selecting an improvement project on the basis of chance. Naturally the "Q" value will change every time the NSC Memo 113 is updated. The formula used to compute "Q" is shown on Figure 10.

The ratio of injuries to fatalities will vary depending on the general class of locations under study. For example, the ratio for rural roadways is considerably different than the ratio for urban roadways.

## PROJECT ANALYSIS BUREAU - PROJECT PLANNING SECTION

BENEFIT/COST RATIO WORK SHEET

Location: FAP Route \_\_\_\_\_ Milepost \_\_\_\_\_

Project Designation: \_\_\_\_\_

Alternate No.: \_\_\_\_\_

Alternate Description: \_\_\_\_\_

Estimated Service Life: \_\_\_\_\_ Year = T

Compounded Interest Rate: \_\_\_\_\_ % = R

Current 19\_\_ ADT \_\_\_\_\_

Time Frame for Accident Data From \_\_\_\_\_ To \_\_\_\_\_ = \_\_\_\_\_ Years

## I ANNUAL COST FOR THE ALTERNATE

1. C = Capital cost for alternate \$ \_\_\_\_\_

2. K = Capital recovery factor =  $K = \frac{R(1+R)^T}{(1+R)^T - 1}$  = \_\_\_\_\_

3. M = Change in annual maintenance or operation costs \$ \_\_\_\_\_

4. Annual cost = (C - K) + M = \$ \_\_\_\_\_

## II ANNUAL BENEFIT OF THE ALTERNATE

1.  $ADT_a$  = Average daily traffic after alternate \_\_\_\_\_2.  $ADT_b$  = Average daily traffic before alternate \_\_\_\_\_

3. I/F = Ratio of injuries to fatalities

for the class of highway involved \_\_\_\_\_

4.  $Q = \frac{(\# \text{ of Fatal Acc.} \times \text{Cost of a Fatal Acc.}) + (\# \text{ of Injury Acc.} \times \text{Cost of Injury Acc.})}{\# \text{ of Fatal Accidents} + \# \text{ of Injury Accidents}}$ 

\* Current Cost of a fatal accident from Federal Highway Administration. At this writing, the FHWA has determined these costs to be: Fatal Accident = \$500,000, Injury Accident = \$11,000, and Property Damage = \$1,500

5.  $A_{fi}$  = Annual average number of fatal accidents and injury accidents combined at the location which will be affected by the alternate =

\_\_\_\_\_ # = \_\_\_\_\_ = \_\_\_\_\_  
Years

6.  $A_{pd}$  = Annual average number of property damage accidents at the location =

\_\_\_\_\_ # = \_\_\_\_\_ = \_\_\_\_\_  
Years



7. PFI = Expected percentage reduction of fatal and injury accidents by alternate \_\_\_\_\_%.
8. Ppd = Expected percentage reduction of property damage accidents by alternate \_\_\_\_\_%.
- $P_1$  = Largest percentage reduction in accidents of any one of the alternates.
  - $P_2$  = Second largest percentage reduction in accidents of any of the alternates.
  - $P_3$  = Third largest.
  - PFI for location where more than one alternate will be used in combination =  

$$P_1 + \frac{100 - P_1}{100} P_2 + \frac{100 - P_1}{100} \frac{100 - P_2}{100} P_3 + \dots$$

9. Annual Benefit =  $ADT_a$   

$$\frac{ADT_b}{ADT_a} [Q(Afi) Pfi + *** (Apd) Ppd]$$

III BENEFIT COST RATIO =  $\frac{\text{Annual Benefit}}{\text{Annual Cost}}$  = \_\_\_\_\_ = \_\_\_\_\_



Now, since "Q" has been defined and fatalities and injuries can be combined, the initial Planned Annual Benefit formula can be stated:

$$\text{Planned Annual Benefit (in dollars)} = Q (Afi) Pfi + Cpd (Apd) Ppd$$

Where; Q = average cost per fatal and injury accidents combined  
Afi = average number of annual fatal or injury accidents combined  
Pfi = expected percent reduction in fatal or injury accidents  
Apd = average annual property damage only accident  
Cpd = cost per property damage only accident (NSC)  
Ppd = expected percent reduction in property damage only accidents

Various improvements at junctions, sections, curves, bridges, etc., are related to a fractional reduction of all accidents. Since many of the improvements may be found in various categories, engineering judgement is required to determine some of the major reductions. No combination of improvements can exceed a 100% reduction in accidents. Table 8 presents some accident reduction forecasting data. Further information can be obtained from other sources including "Accident Reduction Levels Which May Be Attainable From Various Safety Improvements", August 1982, published by the FHWA.

TABLE 8  
ACCIDENT REDUCTION FACTORS  
FOR  
HIGHWAY SAFETY IMPROVEMENT PROJECTS

IMPROVEMENT TYPE	FHWA PROJ.LIFE CODE IN YEARS	PERCENTAGE REDUCTION		IN ACCIDENTS	
		ALL ACCIDENTS	INJURY ACCIDENTS	FATAL ACCIDENTS	DATA SOURCE
NEW TRAFFIC SIGNALS:	11 10	23			KENTUCKY STUDY
4-LEGGED INTERSECTION		18	32	49	FHWA-1977
WITHOUT CHANNELIZATION		24	16	14	EFF. OF SAFETY IMP.
		32			CALIFORNIA-1
		27			CALIFORNIA-2
		15			CALIFORNIA-3
		---	---	---	
AVERAGE=		23	24	31	
LEFT TURN CHANNELIZATION:	10 10	30			KENTUCKY STUDY REC.
AT NON-SIGNALIZED INTER-		50			CALIFORNIA-1
TIONS WITH PAINTED		30			CALIFORNIA-2
CHANNELIZATION IN A RURAL		19			MISSOURI
AREA.		10			MISSISSIPPI
		15	12	43	EFF. OF SAFETY IMP.
		23	29	65	FHWA-1977
		---	---	---	
AVERAGE=		25	20	54	
LEFT TURN CHANNELIZATION	12 10	24			KENTUCKY STUDY
AND NEW TRAFFIC SIGNALS.		36			CALIFORNIA-1
		23	33	74	EFF. OF SAFETY IMPR.
		31	35	50	FHWA-1977
		---	---	---	
AVERAGE=		29	34	62	
LEFT TURN PHASE ON	10	30			KENTUCKY STUDY
TRAFFIC SIGNAL.		36			CALIFORNIA
		---			
AVERAGE=		33			
NEW SAFETY LIGHTING AT	65 15	55			KENTUCKY STUDY REC.
INTERSECTION.		9	9	73	FHWA-1977
(NIGHT ACC. ONLY)		86			CALIF. SPECIAL STDY.
		75			CALIFORNIA
		80			CALIFORNIA
		75			MISSOURI
		---			
AVERAGE=		63			
BREAKAWAY SIGNS OR LIGHT	61 4	15			KENTUCKY STUDY
SUPPORTS		35	44	100	FHWA-1977
		-14	-13		EFF. OF SAFETY IMP.
		---	---		
AVERAGE=		12	15		

TABLE 8 (Continued)  
ACCIDENT REDUCTION FACTORS  
FOR  
HIGHWAY SAFETY IMPROVEMENT PROJECTS

Page No. 2	02/12/88	ACCIDENT REDUCTION FACTORS FOR HIGHWAY SAFETY IMPROVEMENT PROJECTS										Page No. 3	02/12/88	ACCIDENT REDUCTION FACTORS FOR HIGHWAY SAFETY IMPROVEMENT PROJECTS									
IMPROVEMENT TYPE	FHWA PROJ. LIFE CODE IN YEARS	PERCENTAGE ALL ACCIDENTS	REDUCTION INJURY ACCIDENTS	IN ACCIDENTS FATAL ACCIDENTS	DATA SOURCE	IMPROVEMENT TYPE	FHWA PROJ. LIFE CODE IN YEARS	PERCENTAGE ALL ACCIDENTS	REDUCTION INJURY ACCIDENTS	IN ACCIDENTS FATAL ACCIDENTS	DATA SOURCE												
CONTINUOUS LEFT-TURN LANE	5	30			KENTUCKY STUDY REC.						CALIFORNIA												
		33																					
		---																					
AVERAGE=		32																					
REAR END ACC.		62																					
LEFT-TURN ACC.		45																					
SIGHT DIST. IMPROVEMENT	13 20	26	20	57	KENTUCKY STUDY EFF. OF SAFETY IMPR. FHWA-1977	HORIZONTAL REALIGNMENT:	40 20	30	29	26	KENTUCKY STUDY REC. EFF. OF SAFETY IMP.												
		33	29	100				37															
		31	38	36				---															
		---	---	---				34															
AVERAGE=		30	29	64																			
LANES ADDED WITHOUT NEW MEDIAN.	21 20	7	30	74	KENTUCKY STUDY EFF. OF SAFETY IMPR. FHWA-1977	COMBINATION - HORIZONTAL AND VERTICAL REALIGNMENT:	42 20	50	-1	11	KENTUCKY STUDY REC. EFF. OF SAFETY IMPR. FHWA-1977 CALIFORNIA												
		35		31				21	32	69													
		17	11	---				50															
		---	---	---				---	---	---													
AVERAGE=		20	20	52				28	16	40													
SHOULDER WIDENING:	23 20	20			KENTUCKY STUDY REC. EFF. OF SAFETY IMPR. FHWA-1977	DELINEATION - STRIPING EDGES/LINES:	64 4				CALIFORNIA-1												
		-5	-7					25															
		29	20																				
		---	---																				
AVERAGE=		15	6					2			CALIFORNIA-1 KENTUCKY STUDY REC. FHWA-BOB LEE												
FLASHING BEACON AT INTERSECTION:	10	30			KENTUCKY STUDY REC. CALIFORNIA-1 CALIFORNIA-2 MICHIGAN MISSOURI	ALL ACC.		15															
4-LEG REQ-YELLOW:		50						16															
		40						---															
		13						11															
		22																					
		---																					
AVERAGE=		31						36			FHWA-BOB LEE KENTUCKY STUDY												
FLASHING BEACON:								37															
3-LEG REQ-YELLOW:	10	50			KENTUCKY STUDY CALIFORNIA-1 CALIFORNIA-2 ALABAMA MISSOURI	22 FT. PAVEMENT:		---															
		50						37															
		40																					
		34																					
		22						8															
		---																					
AVERAGE=		39						65			CALIFORNIA KENTUCKY STUDY REC.												
4-WAY REQ:		65						40															
								---															

TABLE 8 (Continued)  
ACCIDENT REDUCTION FACTORS  
FOR  
HIGHWAY SAFETY IMPROVEMENT PROJECTS

Page No. 4	Page No. 5																		
02/11/88	02/12/88																		
ACCIDENT REDUCTION FACTORS FOR HIGHWAY SAFETY IMPROVEMENT PROJECTS										ACCIDENT REDUCTION FACTORS FOR HIGHWAY SAFETY IMPROVEMENT PROJECTS									
IMPROVEMENT TYPE										IMPROVEMENT TYPE									
FHWA PROJ. LIFE CODE IN YEARS										FHWA PROJ. LIFE CODE IN YEARS									
PERCENTAGE ALL ACCIDENTS										PERCENTAGE ALL ACCIDENTS									
REDUCTION IN ACCIDENTS										REDUCTION IN ACCIDENTS									
FATAL ACCIDENTS										FATAL ACCIDENTS									
DATA SOURCE										DATA SOURCE									
AVERAGE=										AVERAGE=									
PASSING ACC.:										WET ACCIDENTS:									
DELINEATION- POST MOUNTED 64 4										FENCING:									
GENERAL:										ANIMAL ACC.:									
20 13 25 36 ---										50 90 ---									
AVERAGE=										AVERAGE=									
24 29 35										70									
HORIZONTAL CURVES:										PROTECTIVE GUARDRAIL:									
30 30 ---										62 10									
AVERAGE=										AVERAGE=									
30 40 27 50 ---										33 32 15 -4 ---									
BRIDGE ENDS:										AT BRIDGE ENDS:									
39										20 19 45 90									
TANGENT SECTIONS:										AVERAGE=									
(POST MOUNTED BUTTON)										MEDIAN BARRIER:									
AVERAGE=										63 10									
26										0 26 3 ---									
NIGHT RUN-OFF-ROAD:										AVERAGE=									
NIGHT:										AVERAGE=									
33										10 11 56									
SUPER-ELEVATION CORRECT.:										AT EMBANKMENT CURVES:									
20										50 50 60 ---									
AVERAGE=										AVERAGE=									
44										53									
SKID TREATMENT / OVERLAY:										INSIDE CURVES:									
(ALL ACCIDENTS)										AVERAGE=									
26 20										30 30 24 ---									
19 17 20 29 25 20 20										28 65 65 ---									
27 30										KENTUCKY STUDY CALIFORNIA ALABAMA									
KENTUCKY STUDY REC. FHWA-1977 CALIFORNIA-1 PENNSYLVANIA CALIFORNIA-2 MISSOURI										KENTUCKY STUDY CALIFORNIA-1 CALIFORNIA-2									
EFF. OF SAFETY IMPR.										KENTUCKY STUDY CALIFORNIA KENTUCKY STUDY									

TABLE 8 (Continued)  
ACCIDENT REDUCTION FACTORS  
FOR  
HIGHWAY SAFETY IMPROVEMENT PROJECTS

Page No. 6	02/12/88	ACCIDENT REDUCTION FACTORS FOR HIGHWAY SAFETY IMPROVEMENT PROJECTS									
		FHWA PROJ. LIFE CODE IN YEARS	PERCENTAGE ALL ACCIDENTS	REDUCTION INJURY ACCIDENTS	IN ACCIDENTS FATAL ACCIDENTS	DATA SOURCE					
SIGNING: CURVE WARNING ARROW:		60 5	65								
			20			KENTUCKY STUDY					
			20			CALIFORNIA-1					
			18			CALIFORNIA-2					
		AVERAGE=	---								
			19								
CURVE W/SPEED PLATE:			30			KENTUCKY STUDY REC.					
			20			CALIFORNIA-1					
			22			CALIF. MINOR IMPR.					
			45			CALIF. SPCL. STUDY					
		AVERAGE=	---								
			29								
4-WAY STOP:			63			KENTUCKY STUDY					
			70			CALIFORNIA					
			73			CALIF. MINOR IMPR.					
			19			ALABAMA					
			75			CALIF. SPEC. STUDY					
		AVERAGE=	---								
			60								
ADVISORY SPEED:			36			CALIFORNIA					
			36			KENTUCKY STUDY					
		AVERAGE=	---								
			36								
GENERAL: ALL SIGNING: DARK ACC.:			52			PENNSYLVANIA					
			76			PENNSYLVANIA					
RECONSTRUCTION: (COMBINATIONS & MISC.)		29 20	18	27	47	EFF. OF SAFETY IMPR. CALIF. SPCL. STUDY					
			42			CALIFORNIA-1					
			25			CALIFORNIA-2					
			20			MISSOURI					
			25								
		AVERAGE=	---								
			26								
REPLACEMENT OF BRIDGE OR OTHER MAJOR STRUCTURE:		31 30	38	66	100	KENTUCKY STUDY					
			44	60	47	FHWA-1977					
			3	19	48	EFF. OF SAFETY IMPR.					
		AVERAGE=	---	---	---						

Page No. 7	02/12/88	ACCIDENT REDUCTION FACTORS FOR HIGHWAY SAFETY IMPROVEMENT PROJECTS									
		FHWA PROJ. LIFE CODE IN YEARS	PERCENTAGE ALL ACCIDENTS	REDUCTION INJURY ACCIDENTS	IN ACCIDENTS FATAL ACCIDENTS	DATA SOURCE					
WIDENING BRIDGE OR OR MAJOR STRUCTURE:		30 20	28	48	65						
			49	56	50	KENTUCKY STUDY					
			65	74	33	FHWA-1977					
			18	25	100	EFF. OF SAFETY					
		AVERAGE=	---	---	---						
			44	52	61						
PAVEMENT WIDENING:		20 20	32			KENTUCKY STUDY					
			25	38	87	FHWA-1977					
			5	-9	81	EFF. OF SAFETY IMPR.					
			53			PENNSYLVANIA					
		AVERAGE=	---	---	---						
			29	14	84						
DARK ACC.:			62			PENNSYLVANIA					
HEADON ACC.:			86			PENNSYLVANIA					
OTHER IMPROVEMENTS: STOP AHEAD SIGN:		60 5	47			KENTUCKY STUDY REC.					
			40			KENTUCKY STUDY REC.					
RURAL INTERSECTION SIGN:		60 5	15			KENTUCKY STUDY REC.					
			26			MONTANA STUDIES					
		AVERAGE=	---								
			21								
RUMBLE STRIPS: AT ROAD SHOULDER:		5	26			KENTUCKY STUDY REC.					
AT T-INTERSECTIONS: (ALL ACC.)		5	12			EFF. OF SAFETY IMPR. FHWA-1982					
			44								
		AVERAGE=	---								
			28								
CURVE RECONSTRUCTION:		29 20	50			KENTUCKY STUDY REC.					
CHEVRON SIGNING:		60 5	33			MONTANA STUDIES					
			30			KENTUCKY STUDY REC.					
		AVERAGE=	---								
			32								



It is also felt that traffic volume can greatly influence the quantity and quality of accidents. In order to counter the effect of average daily traffic (ADT) on accidents and, therefore, benefits, the projected ADT<sub>a</sub> (After) is divided by the current ADT<sub>b</sub> (Before). The expected average annual benefit is multiplied by this factor to yield the adjusted average annual expected benefit. The expected benefit formula now becomes:

$$B = \frac{ADT_a}{ADT_b} [Q (Afi) Pfi + Cpd (Apd) Ppd]$$

Where: B = expected Annual Benefit (in dollars)  
 ADT<sub>a</sub> = projected Average Daily Traffic after improvement  
 ADT<sub>b</sub> = Average Daily Traffic before improvement

This is now the working formula for planned benefit.

If more than one solution strategy is being implemented and each strategy has a quantifiable percent reduction the cumulative percent reduction is computed thusly:

$$P = p1 + \frac{(100-p1)}{100} p2 + \frac{(100-p1)}{100} \frac{(100-p2)}{100} p3 + \text{-----}$$

Where; P = Cumulative percent  
 p1 = Percent reduction for strategy 1  
 p2 = Percent reduction for strategy 2  
 p3 = Percent reduction for strategy 3  
 etc.

The planned cost concept, in general, is that

1. The total economic cost of each proposed improvement alternate can be readily calculated.
2. The formula for capitol recovery factor is:

$$K = \frac{R (1 + R)^T}{(1 + R)^{T-1}}$$

Where; R = Compounded interest rate  
 T = Estimated service life

With the capitol recovery factor explained, the formula for annual cost is:

$$\text{Annual Cost} = [C(K)] + M$$

Where; C = Capitol costs  
 K = Capitol recovery factor  
 M = change in annual maintenance or operation costs.

Figure 10 can be used to compute the benefit-cost ratio for improvements to reduce accidents. Once the benefit-cost ratio has been computed, a Benefit-Cost Index Value is determined from Figure 11.

The Priority Index for long term improvements is a weighted average of the Hazard Index and the Benefit-Cost Index. The Hazard Index is weighted 0.75 and the Benefit-Cost Index is weighted 0.25. The Long Term Priority Index formula thus takes the following form:

$$\text{L.P.I.} = 0.75 (\text{H.I.}) + 0.25 (\text{B/C.I.})$$

The weighting factors used in the Priority Index formula are based on the sum of the applicable weights found in the Report FHWA-RD-77-83 for those indicators used in the Cascade County recommended program. A high Priority Index indicates the improvements at a location are more cost effective than those at a location with a lower Priority Index.

Conclusions. Once the Priority Index(es) for each location have been determined as discussed above, short term and long term priority lists can be prepared by ranking the locations from highest Priority Index to lowest Priority Index. A form for the determination of the Hazard Index and Priority Index is provided on Figure 12.

Since the Hazard Index and the Priority Index are not dependent on the number of locations studied, an ongoing program can be established whereby locations are evaluated as time and budgetary restrictions permit. The priority list can be adjusted according to the Priority Index as new locations are evaluated.

Continued monitoring of hazardous locations will be an important element of this program. Changes in traffic volumes or other conditions may necessitate a re-evaluation of a particular location. Also the effectiveness of improvements made at a location can be analyzed by future evaluation of the Hazard Index for that location. Any re-evaluation should not be made for at least four years after the improvements were made so that the data used in the re-evaluation will reflect the modified condition of the location.

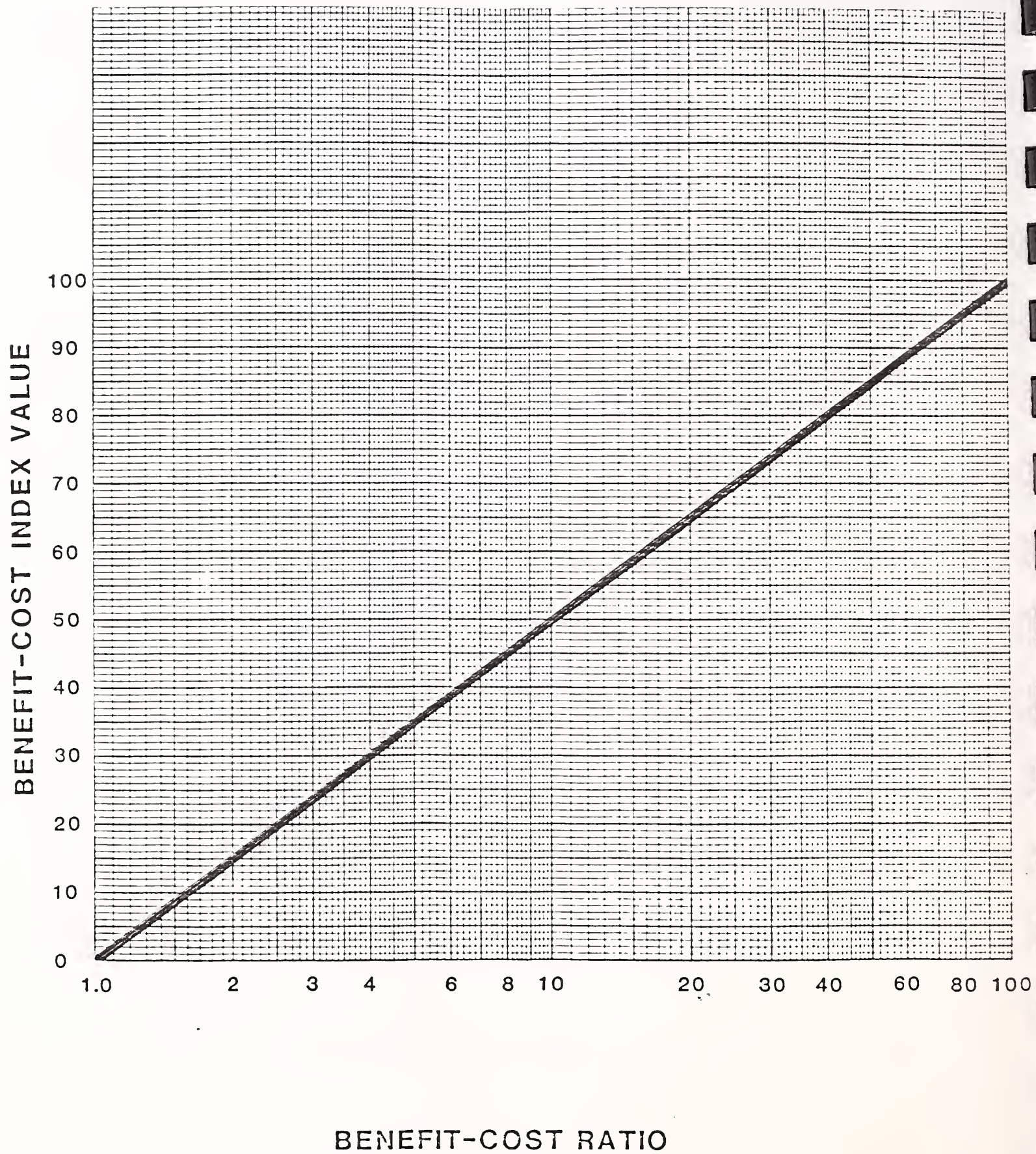


FIGURE 11



Figure 12  
**RECOMMENDED PROGRAM**  
 CASCADE COUNTY, MONTANA  
 DETERMINATION OF PRIORITY INDEX

Site Number \_\_\_\_\_  
 Site Description \_\_\_\_\_

HAZARD INDEX (H.I.)

<u>Indicator</u>	<u>Data Value</u>	<u>Indicator Value</u>	<u>Weight</u>	<u>Partial H.I.'s</u>
Number of Accidents	_____acc/yr	_____	x 0.194	_____
Accident Rate	_____acc/MEV	_____	x 0.266	_____
Accident Severity	_____dollars	_____	x 0.226	_____
Driver Expectancy	_____ (wt avg)	_____	x 0.117	_____
Information System	_____ (wt avg)	_____	x 0.137	_____

H.I. =  $\frac{\text{Sum of Partial H.I.'s}}{\text{Sum of Applicable Weights}}$  = \_\_\_\_\_ = \_\_\_\_\_

Relative Strength of Evaluation:  
 Sum of Applicable Weights x 100 = \_\_\_\_\_%

\*Do not include weights for indicators not used at this site.

PRIORITY INDEX FOR SHORT TERM IMPROVEMENTS (S.P.I.)

S.P.I. = H.I. = \_\_\_\_\_

PRIORITY INDEX FOR LONG TERM IMPROVEMENTS (L.P.I.)

Benefit-Cost Ratio = \_\_\_\_\_

B/C Index Value = \_\_\_\_\_

L.P.I. =  $0.75 \times (\text{H.I.}) + 0.25 \times (\text{B/C.I.})$

=  $0.75 \times \text{_____} + 0.25 \times \text{_____}$

L.P.I. = \_\_\_\_\_

Figure 12. Form for Determination of Priority Index





## EVALUATION AND RECOMMENDATIONS BY LOCATION



## EVALUATION AND RECOMMENDATIONS BY LOCATION

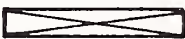



Each of the nine locations referenced on pages 6 and 7 has been analyzed using the recommended evaluation program and the sight distance indicator value. The results of this analysis are presented in summary form in Tables 1 and 2.

This section of the report discusses the evaluation and recommendations for each location. Information is presented in the following order by location:

- Evaluation and Recommendations
- Accident Summary Form
- Priority Index Determination Form (with sight distance indicator)
- Site Photographs
- Condition/Accident Diagram
- Recommended Improvement Diagram(s) (if applicable)

A legend for use with the accident diagrams is found on Figure 13. Recommended improvements at some locations include installation of delineators. Delineators are referenced in accordance with Montana Department of Highways standards. MDOH delineator designs and legend are shown on Figure 14. MDOH delineator placement standards are shown on Figure 15.

## ACCIDENT DIAGRAM LEGEND

PATH OF MOVING MOTOR VEHICLE	—————	—————
PEDESTRIAN PATH	—————	- - - - -
REAR-END COLLISION	—————	—————+—————
OUT OF CONTROL	—————	—————o o o o o—————
SIDE SWIPE	—————	—————/—————
BACKING COLLISION	—————	—————+<<<<—————
PARKED VEHICLE	—————	
FIXED OBJECT	—————	
PERSONAL INJURY	—————	
FATAL INJURY	—————	

PAVEMENT: 1.DRY 2.WET 3.SNOWY 4.ICY 5.OTHER

WEATHER: 1.CLEAR 2.RAINING 3.SNOWING 4.FOG 5. OTHER

LIGHT: 1.DAY 2.DUSK 3.DAWN 4.DARK-LIGHTED 5. DARK-UNLIGHTED

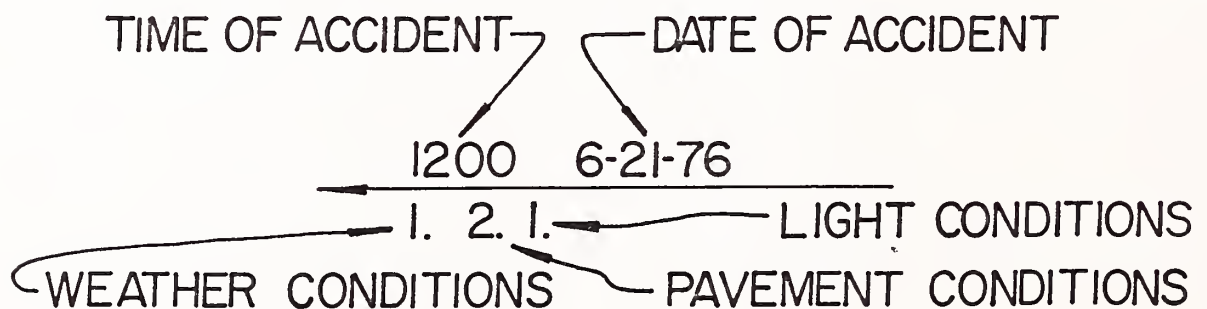


Figure 13

Figure 14

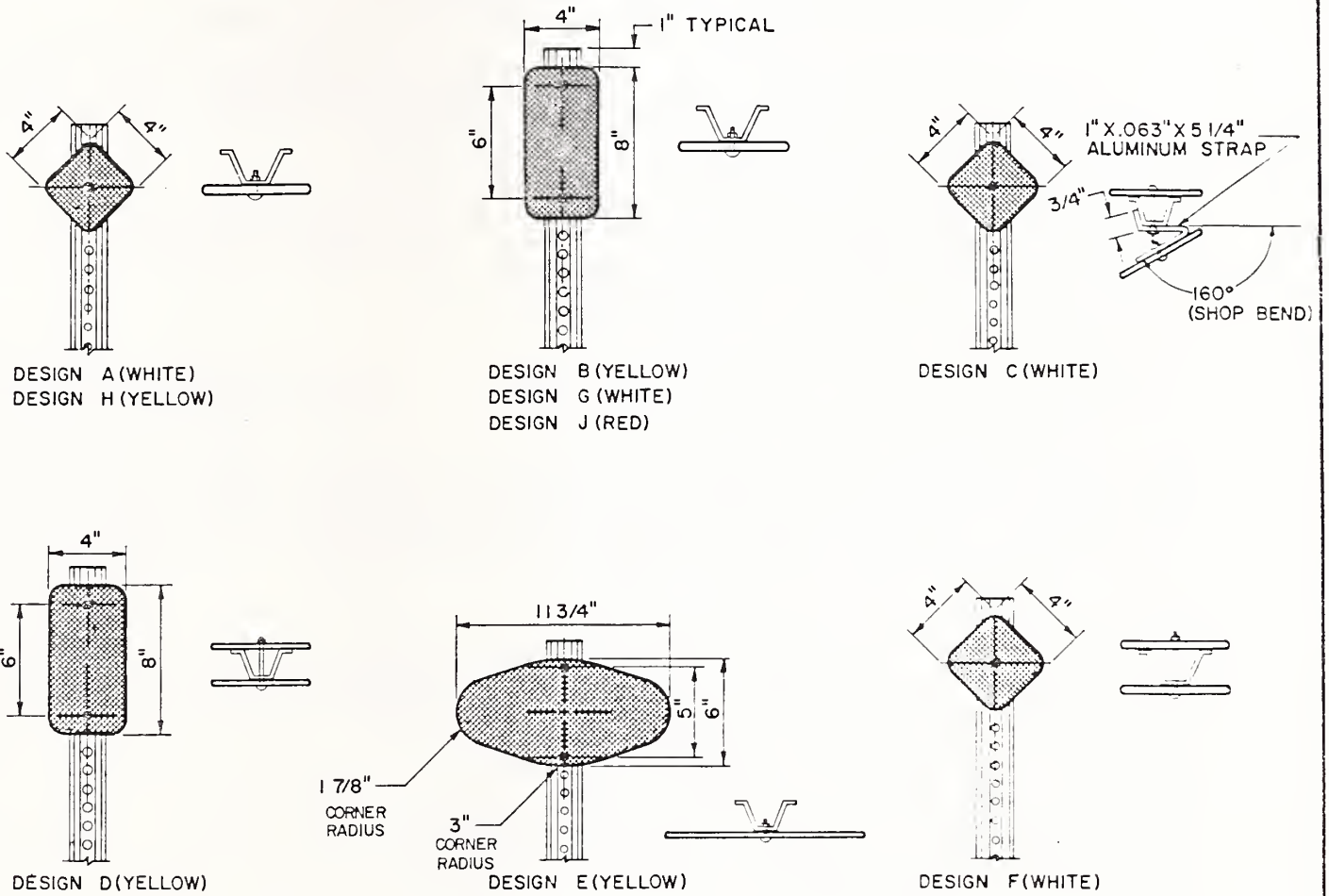


TABLE II

DELINEATOR	LEGEND
DESIGN "A"	—
DESIGN "B"	—
DESIGN "C"	—Y
DESIGN "D"	— —
DESIGN "E"	—
DESIGN "F"	—
DESIGN "G"	—<
DESIGN "H"	—>
DESIGN "J"	—X

SIGNING STANDARD  
DRAWING NUMBER 242

DELINEATOR DESIGN  
AND LEGEND

APPROVED  
BY *[Signature]*  
ADMINISTRATOR'S DEPT.

REVISED	4/1/79	1/84
EFFECTIVE	6/1/79	4/1/84



Figure 15

## NOTES

1. REFLECTIVE SHEETING SHALL BE FURNISHED ACCORDING TO STANDARD SPECIFICATIONS FOR ENCAPSULATED LENS WIDE ANGLE. POSITION DELINEATOR FACES PERPENDICULAR TO TANGENT TO CENTER LINE OF CURVE AS SHOWN IN FIGURE B.
2. DELINEATORS SHALL BE MOUNTED ON METAL U POSTS WITH 3/16" CADMIUM PLATED BOLT(S). A MINIMUM OF 12 1/4" DIAMETER HOLES SHALL BE DRILLED OR PUNCHED ON 1" CENTERS FROM THE TOP OF THE POST. 1/4" SQUARE HOLES MAY BE USED. IF SQUARE HOLES ARE USED A LARGE HEADED BOLT OR AN APPROPRIATE WASHER MUST BE USED. THREADS SHALL BE JAMMED AFTER TIGHTENING THE NUT TO PREVENT REMOVAL.
3. DELINEATORS SHALL BE PLACED AT A CONSTANT CLEARANCE FROM THE EDGE OF PAVEMENT EXCEPT WHERE GUARDRAIL OR OTHER OBSTRUCTION INTERFERES. DELINEATORS SHALL THEN BE IN LINE WITH THE INSIDE EDGE OF THE OBSTRUCTION. CLEARANCE FOR DELINEATORS SHALL BE 6'-0" ON INTERSTATE HIGHWAYS, 2'-0" TO 8'-0" ON PRIMARY AND SECONDARY HIGHWAYS AS DETERMINED BY THE PROJECT ENGINEER. STANDARD MOUNTING HEIGHT SHALL BE 4'-0". POST LENGTHS SHALL BE SUPPLIED TO MAINTAIN THE PROPER MOUNTING HEIGHT AND A MINIMUM OF 18" EMBEDMENT.
4. DELINEATORS SHALL BE SPACED ACCORDING TO THE DISTANCES FOUND IN TABLE I. DELINEATORS THAT ARE TO BE SPACED DIFFERENTLY WILL BE NOTED IN THE PLANS AS TO THEIR PLACEMENT. IN FIGURE A IF "F" DISTANCE IS GREATER THAN 20' ADD ONE REGULAR DELINEATOR IN AT "A" SPACING. UNDER NORMAL SPACING, SHOULD A DELINEATOR FALL WITHIN A CROSSROAD OR APPROACH, IT MAY BE MOVED IN EITHER DIRECTION A DISTANCE NOT TO EXCEED ONE QUARTER OF THE NORMAL SPACING. DELINEATORS STILL FALLING WITHIN SUCH AREAS SHALL BE ELIMINATED.
5. FIGURE C IS A FIELD METHOD FOR DETERMINING DEGREE OF HORIZONTAL CURVES.
6. ALL DELINEATOR REFLECTORS SHALL HAVE 3/4" CORNER RADII EXCEPT DESIGN "E".
7. THE DELINEATOR REFLECTOR SHALL BE MOUNTED 1" BELOW THE TOP OF THE METAL U POST.

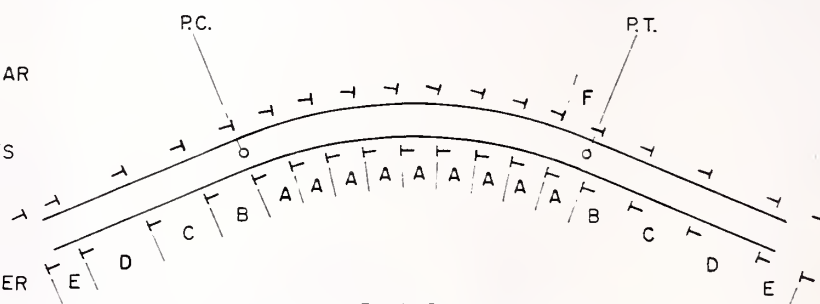


FIGURE A  
SEE TABLE I FOR SPACING VALUES

TABLE I

DEGREE OF CURVE	HORIZONTAL CURVE SPACING TABLE				
	SPACING ON CURVE A	SPACING ON BOTH APPROACH TANGENTS			
		B	C	D	E
0°+ TO 30'	300'	400'	400'	400'	400'
30°+ TO 1°	300'	400'	400'	400'	400'
1°+ TO 2°	225'	400'	400'	400'	400'
2°+ TO 3°	160'	320'	400'	400'	400'
3°+ TO 4°	130'	260'	400'	400'	400'
4°+ TO 6°	110'	220'	330'	400'	400'
6°+ TO 8°	90'	185'	275'	400'	400'
8°+ TO 12°	75'	150'	230'	300'	400'
12°+ TO 20°	60'	125'	185'	300'	400'
20° PLUS	45'	90'	140'	275'	400'



FIGURE B

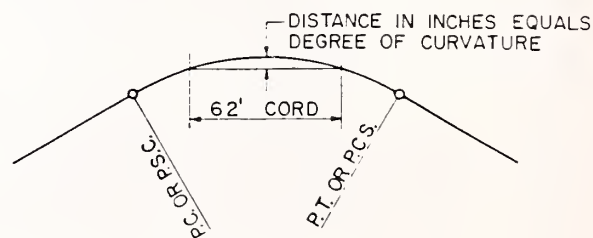


FIGURE C

SIGNING STANDARD  
DRAWING NUMBER 243

DELINEATOR PLACEMENT  
DETAILS AND NOTES

REVISED	4/1/79	1/84
EFFECTIVE	6/1/79	4/1/84

APPROVED  
BY *John H. Smith*  
ALTERNATE PROJECT ENGINEER

LOCATION NO. 1  
Giant Springs Road - Rainbow Dam Area

This site is a paved, two lane, two way, rural stretch of Giant Springs Road beginning approximately .4 miles east of Giant Springs State Park. The site is located in the northeast quadrant of Great Falls, and is approximately .6 miles in length. A railroad overpass traverses the site near the east boundary. The road provides many scenic vistas of the Missouri River which borders the site to the north.

#### EVALUATION

##### Traffic Volumes

The 1989 two-way ADT on Giant Springs Road was 753 vehicles per day. This was up 32% from a 1987 count of 570 vehicles. Data was provided by City of Great Falls and City/County Planning.

##### Signing

This site has posted speed limits of 30 MPH in each direction. There are supplemental speed plates on several curve signs throughout the site. The advisory speed limit thru curves is 20 MPH. This was field verified with a ball bank indicator at this site. Throughout the site area, red advisory signs cautioning to beware of unstable banks or other natural hazards during low water exist near the river. There are many gravel pullouts throughout the site. In the vicinity of most of these, the double yellow centerline stripe continues through the pull out area uninterrupted. There are type 1 object markers for both eastbound and westbound traffic at appropriate hazards or guardrail ends. There are design "F" type delineators throughout most of the project site.

##### Accidents

Five accidents occurred during the study period at this site. Only one of the winter season accidents occurred during a snowstorm on icy roadway conditions. Two accidents involved mechanical problems. Most accidents involved failure to maintain control of the vehicle during dry roadway conditions, however there was one rear end accident. Just after the study period another accident occurred which was not analyzed.

##### Contributing Factors

Contributing factors to accidents at this location are:

- Poor sight distance around curve;
- The vista opportunities presented by the roadway throughout the alignment toward the Missouri River diverting drivers attention from the roadway;

- Random location and spacing of the shoulder turnouts scattered throughout the site;
- Vehicle/mechanical problems;
- Vehicle speeds in excess of safe and prudent operating speed for the roadway conditions encountered.

#### RECOMMENDED IMPROVEMENTS-GIANT SPRINGS ROAD

##### Short-Term

The following short term improvements are recommended to improve the safety of this location:

- Maintain the spacing of the design "F" delineators throughout the project site, especially throughout the last curve near the railroad overpass;
- Remove brush on both sides of the road throughout the curves to improve sight distance;
- Install D6-2 scenic overlook ½ mile sign to deter use of the random viewing pull outs along the Missouri River throughout the site;
- Replace the steel cable guardrail with MDOH metal guardrail and install Type 1 terminal sections on all ends;
- Decrease the spacing on the Chevron alignment signs throughout the curve beneath the railroad overpass;
- Install new W-1-6 arrow right for eastbound traffic just east of the railroad overpass.

The preliminary cost estimate for the improvements at this site is \$15,120. Of this cost, approximately \$14,320 is eligible for FHWA funding.

##### Long-Term

There are no long term improvements recommended at this location.

# ACCIDENT DATA

SITE NUMBER 1

ACCIDENT PERIOD 1986 - 1988

		86	87	88
		3	1	1

## NUMBER OF ACCIDENTS BY MONTH

JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
2					1		2				

## NUMBER OF ACCIDENTS BY DAY OF WEEK

SUN	MON	TUES	WED	THURS	FRI	SAT
1	2		1			1

## NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

CLEAR	RAINING	SNOWING	FOG	OTHER
4		1		

## NUMBER OF ACCIDENTS BY ROAD CONDITIONS

DRY	WET	SNOWY	ICY	OTHER
4			1	

## NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

DAYLIGHT	DARK OR DUSK	DARK, LIGHTED	DARK, UNLIGHTED
2			3

## NUMBER OF ACCIDENTS BY ACCIDENT TYPE

ANGLE	R-END	FX-OBJ	PED	BACKING	SIDWYP	NON-COL	HEAD-ON	LIVESTOCK
	1	2			1	1		

## NUMBER OF ACCIDENTS BY NUMBER OF INJURIES

0	1	2	3	4	5
3	1	1			

## NUMBER OF ACCIDENTS BY NUMBER OF FATALITIES

0	1	2	3	4	5
5					

YEARLY SUMMARY OF NUMBER OF INJURIES, NUMBER OF FATALITIES,  
AND NUMBER OF PROPERTY DAMAGE ONLY

	86	87	88
No. inj.		1	1
No. fatal.			
No. P.D.O.		2	1

RECOMMENDED PROGRAM  
WITH SIGHT DISTANCE INDICATOR  
CASCADE COUNTY, MONTANA  
DETERMINATION OF PRIORITY INDEX

Site Number 1  
Site Description Giant Springs Road - Rainbow Dam Area

PRIORITY INDEX FOR SHORT TERM IMPROVEMENTS (S.P.I.)

From Table 6:

S.P.I. = H.I. = 44.76

PRIORITY INDEX FOR LONG TERM IMPROVEMENTS (L.P.I.)

Benefit-Cost Ratio = 0.96

B/C Index Value = 0

L.P.I. =  $0.75 \times (\text{H.I.}) + 0.25 \times (\text{B/C.I.})$

=  $0.75 \times \underline{44.76} + 0.25 \times \underline{0}$

L.P.I. = 33.57

Form for Determination of Priority Index





SITE 1: On Giant Springs Road approximately .35 miles east of Giant Springs State Park looking east. This location is just 200' west of the west border of Site 1. Note the site distance restriction created by the tall bush on the north edge of Giant Springs Road. (1/14)



SITE 1: Taken 500' east of the west site boundary looking west. There is a red pickup truck emerging from behind the bush. (2/3)









SITE 1: On Giant Springs Road approximately .5 miles east of Giant Springs State Park looking east. This location is approximately 400' east of the west boundary of Site 1. (1/16)



SITE 1: Giant Springs Road approximately .78 miles east of Giant Springs State Park looking east. This location is approximately 300' east of the cutslope in the previous picture. Once the driver clears the cutslope, site distance to the railroad overpass is unrestricted. The type 1 object marker on the left is at the beginning of the cable type guardrail. Note the "W1-1R", with 20 mph advisory speedplate on the right. There are type A+F delineators on the north side of the roadway to and beyond the railroad overpass. (1/18)







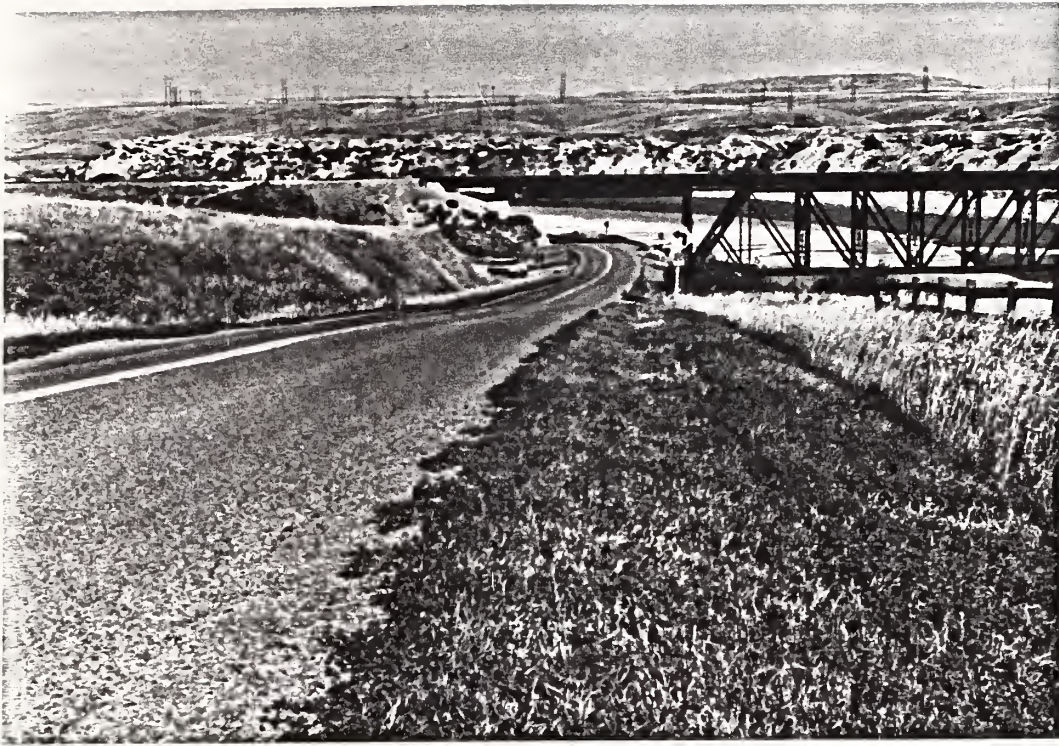
SITE 1: On Giant Springs Rd. near the center of the curve approximately 1,000' west of the railroad overpass looking west. (1/25)



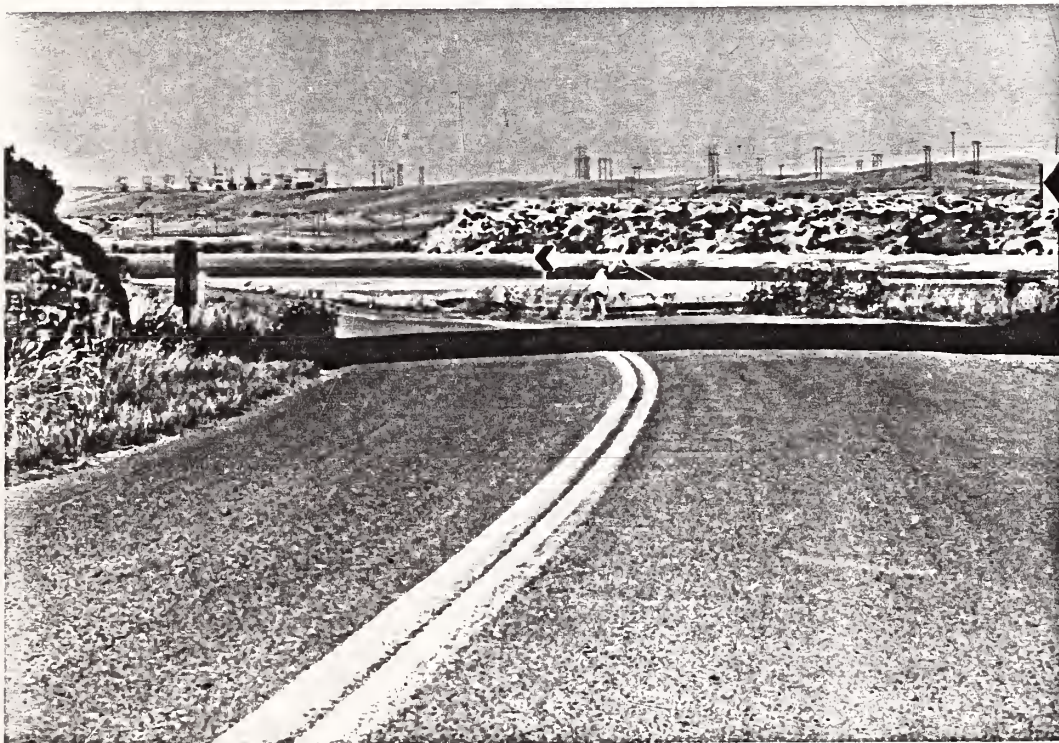
SITE 1: Located approximately 50' west of the railroad overpass across Giant Springs Rd. looking east. This photo is taken from the approximate drivers eye location. (1/20)







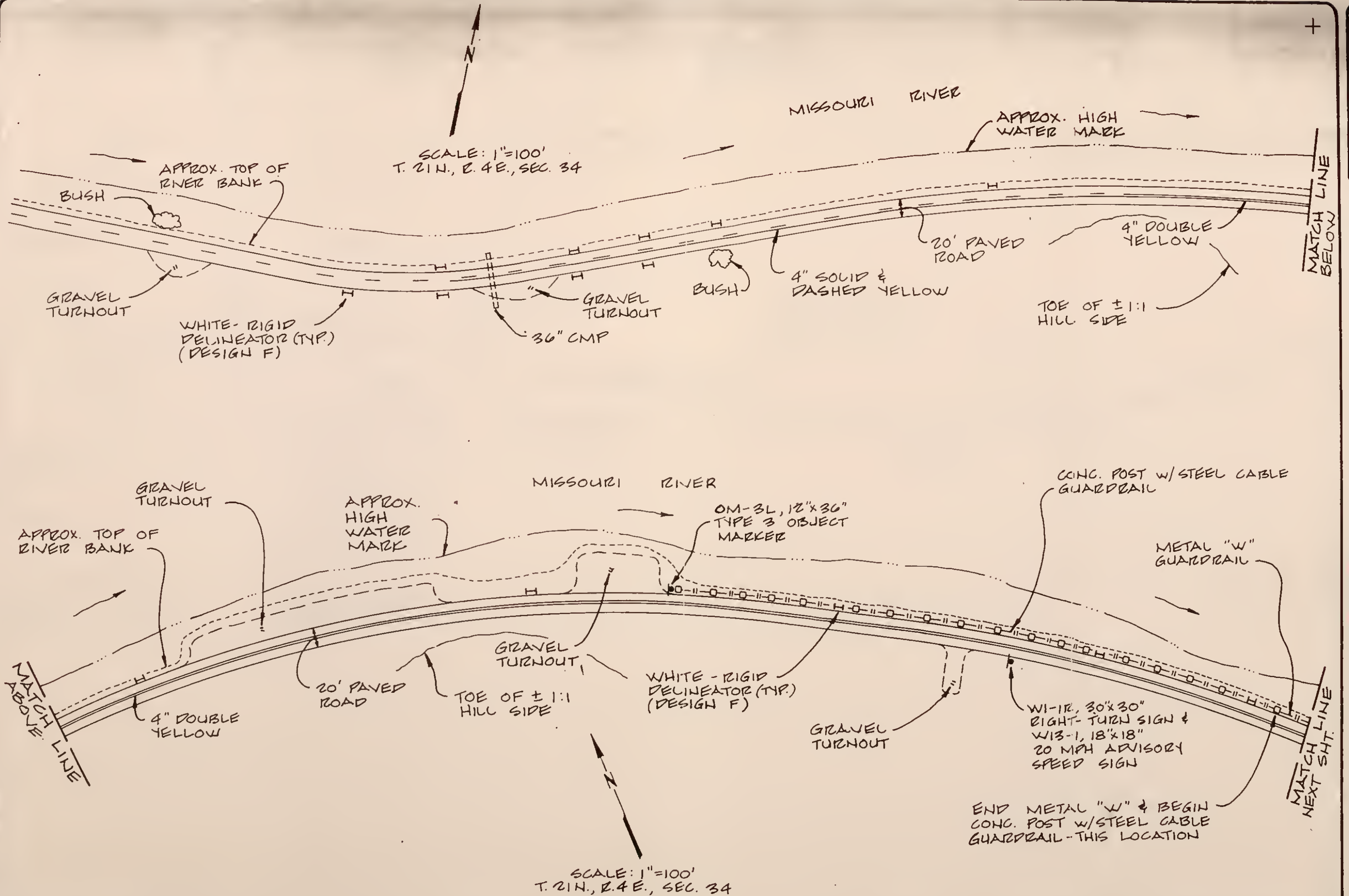
SITE 1: On Giant Springs Rd. approximately 1.1 miles east of Giant Springs State Park. Note the hillside and railroad overpass on the left. (1/22)



SITE 1: On Giant Springs Rd. approximately 40' east of the railroad underpass looking west. (1/23)







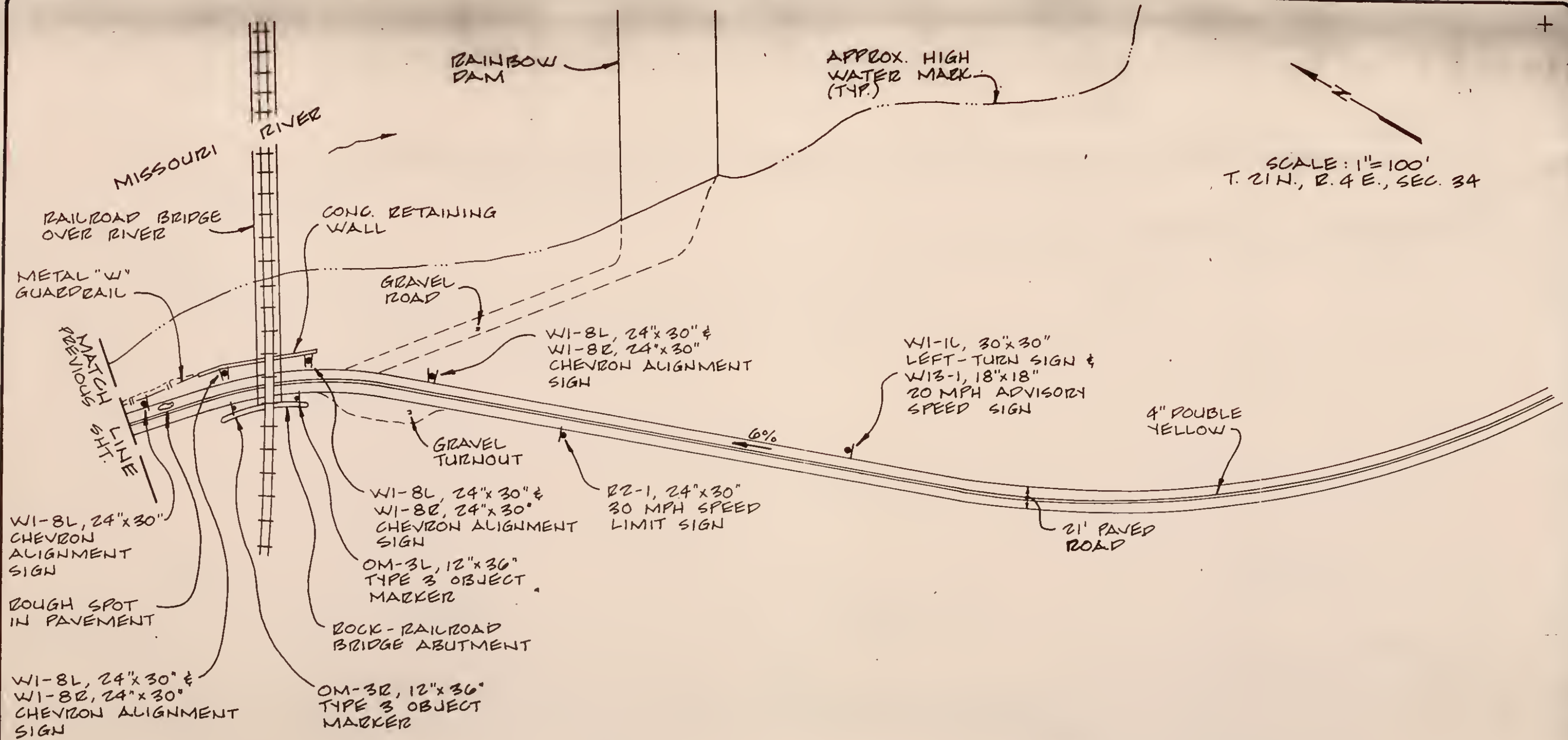
# **CONDITION DIAGRAM** **GIANT SPRINGS ROAD**

**SITE 1**

**HKA ASSOCIATES**  
ENGINEERS - PLANNERS  
2M144.103 SEPT., 1989





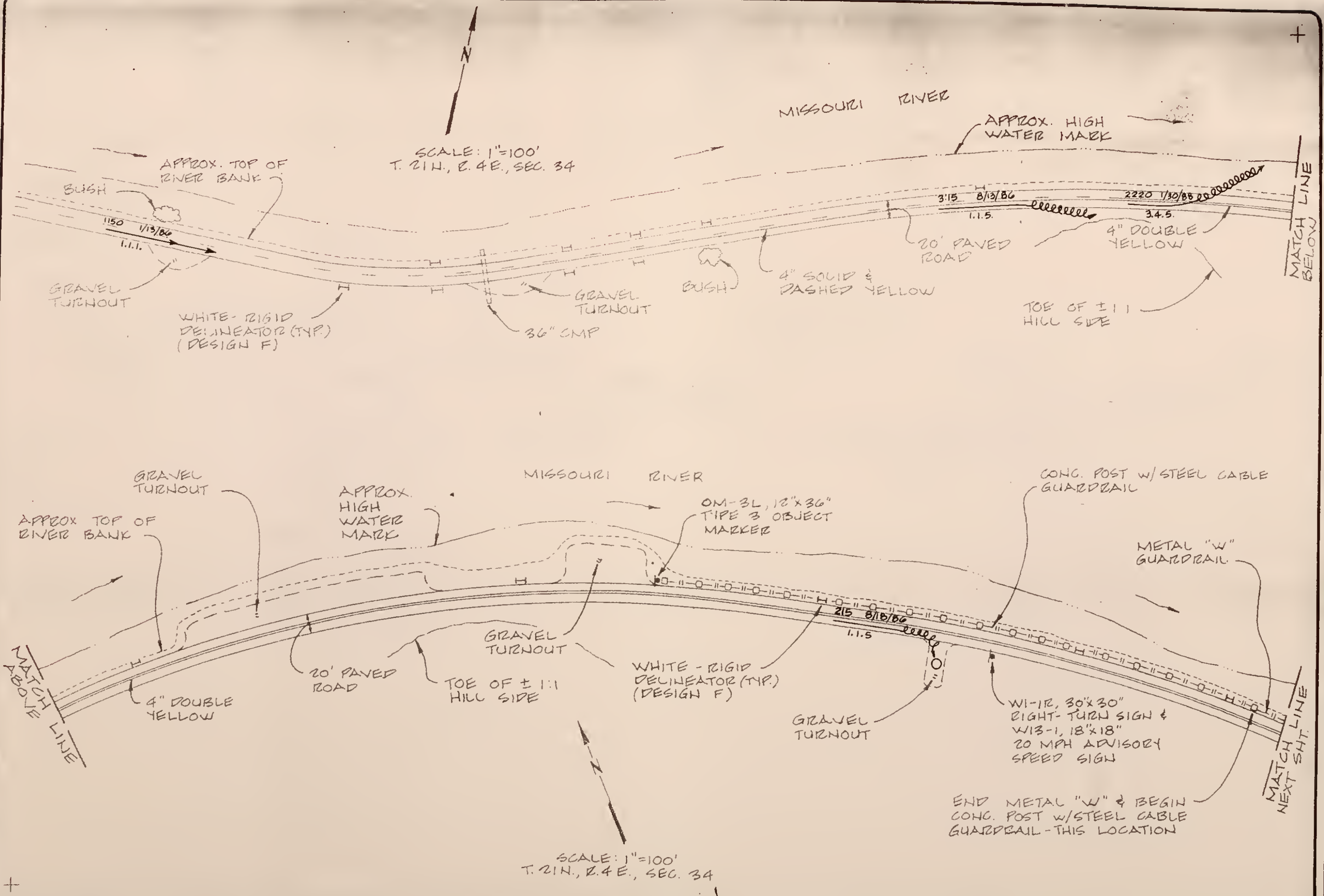


# **CONDITION DIAGRAM** GIANT SPRINGS ROAD

SITE 1

HKA ASSOCIATES  
ENGINEERS - PLANNERS  
2M144.103 SEPT., 1989





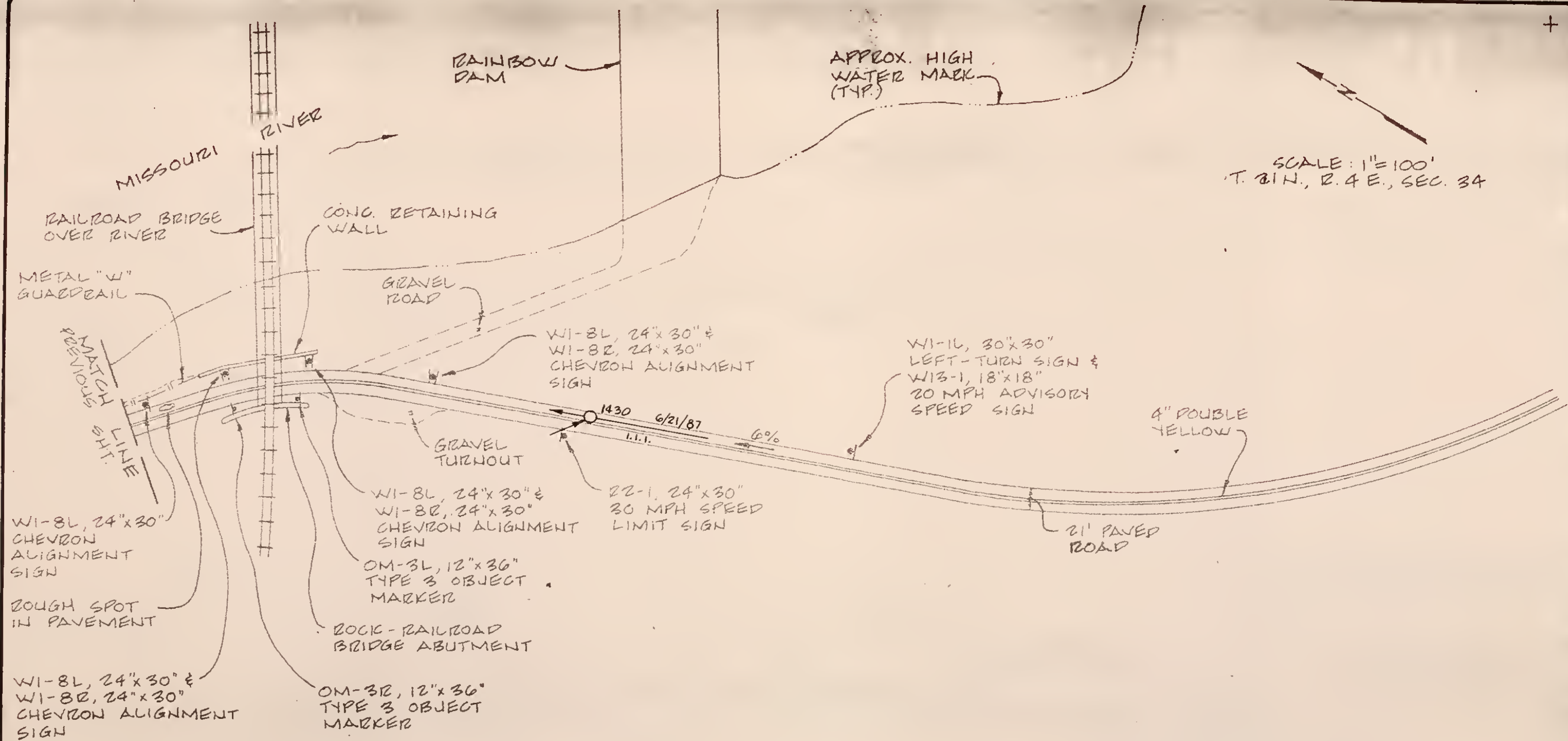
# **ACCIDENT DIAGRAM** **GIANT SPRINGS ROAD**

**SITE 1**

**HKA ASSOCIATES**  
**ENGINEERS - PLANNERS**  
2M144.103 SEPT., 1989







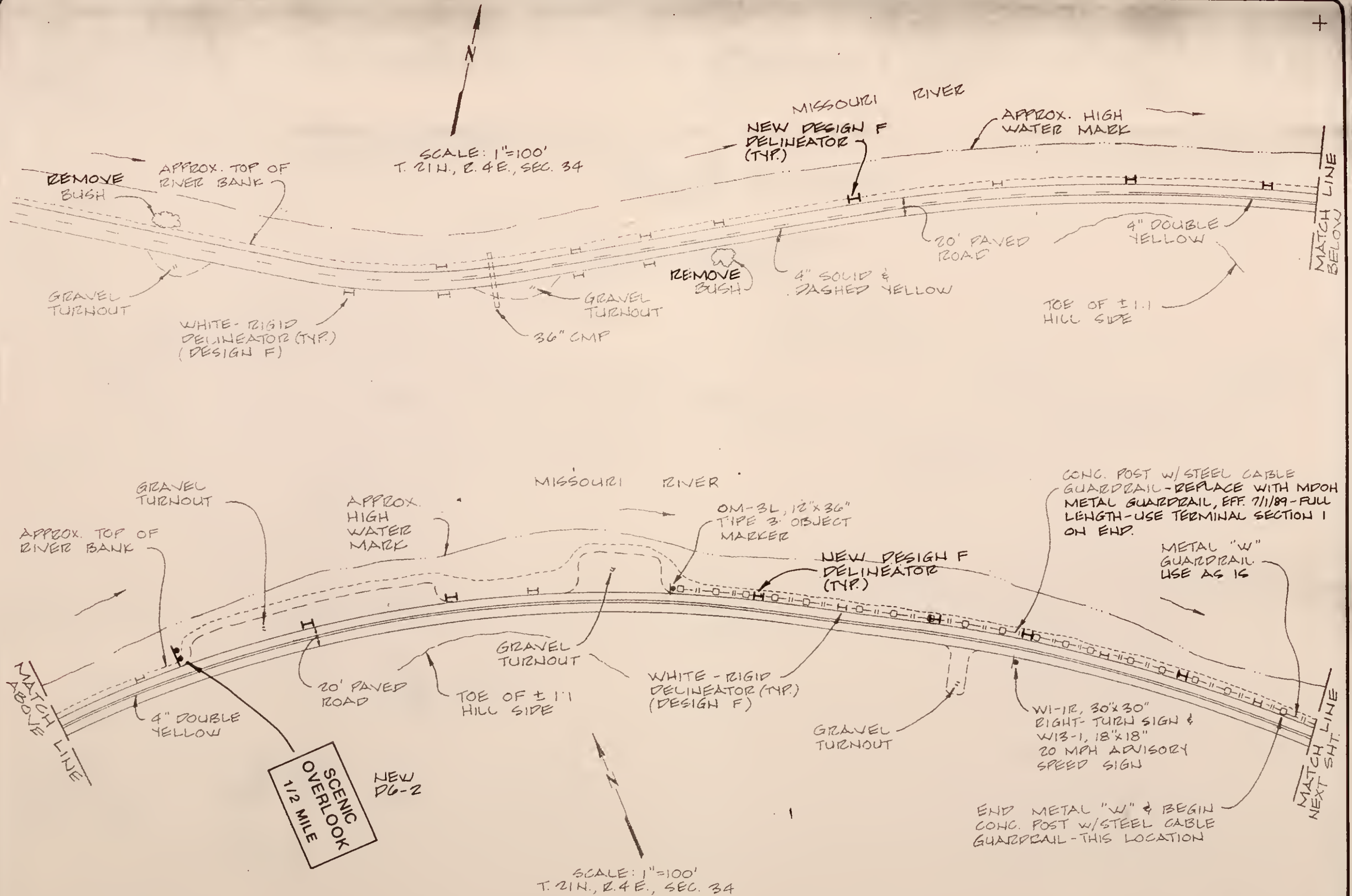
# **ACCIDENT DIAGRAM** GIANT SPRINGS ROAD

**SITE 1**

**HKA ASSOCIATES**  
ENGINEERS - PLANNERS  
20144.103 SEPT., 1980







**RECOMMENDED IMPROVEMENTS (SHORT TERM)**  
GIANT SPRINGS ROAD

SITE 1

HKA ASSOCIATES  
ENGINEERS - PLANNERS  
2M144.103 SEPT., 1989



REMOVE ONE SECTION  
OF EXIST. GUARDRAIL  
FROM CONG. WALL &  
CONNECT NEW METAL  
GUARDRAIL TO EXIST.  
GUARDRAIL POST

MISSOURI  
RAILROAD BRIDGE  
OVER RIVER

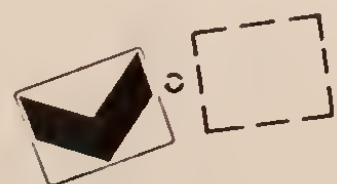
METAL "W"  
GUARDRAIL

PREVIOUS  
SHT.

WI-8L, 24"x30"  
CHEVRON  
ALIGNMENT  
SIGN

ROUGH SPOT  
IN PAVEMENT

WI-8L, 24"x30" &  
WI-8R, 24"x30"  
CHEVRON ALIGNMENT  
SIGN



NEW  
W1-8R  
24"x30"  
MOUNT ON  
EXIST. POST



NEW  
W1-8L  
24"x30"



NEW  
W1-6R  
48"x24"

NEW  
W1-8L  
24"x30"

RAINBOW  
DAM

NEW FILL AREA AS  
REQUIRED TO INSTALL  
NEW GUARDRAIL

CONG. RETAINING  
WALL

GRAVEL  
ROAD

WI-8L, 24"x30" &  
WI-8R, 24"x30"  
CHEVRON ALIGNMENT  
SIGN

GRAVEL  
TURNOUT

WI-8L, 24"x30" &  
WI-8R, 24"x30"  
CHEVRON ALIGNMENT  
SIGN

OM-3L, 12"x36"  
TYPE 3 OBJECT  
MARKER

ROCK-RAILROAD  
BRIDGE ABUTMENT

OM-3R, 12"x36"  
TYPE 3 OBJECT  
MARKER

NEW MPOH METAL GUARDRAIL  
EFF. 7/1/89 WITH TERMINAL  
SECTION 1

NEW MPOH METAL GUARDRAIL  
EFF. 7/1/89 WITH TERMINAL  
SECTION 1 ON BOTH ENDS

W1-1L, 30"x30"  
LEFT-TURN SIGN &  
W13-1, 18"x18"  
20 MPH ADVISORY  
SPEED SIGN

22-1, 24"x30"  
30 MPH SPEED  
LIMIT SIGN

4" DOUBLE  
YELLOW

21' PAVED  
ROAD

APPROX. HIGH  
WATER MARK  
(TYP.)

SCALE: 1"=100'  
T. 21 N., R. 4 E, SEC. 34

RECOMMENDED IMPROVEMENTS(SHORT TERM)

GIANT SPRINGS ROAD

SITE 1

HKA ASSOCIATES  
ENGINEERS - PLANNERS  
20144.103 SEPT., 1999





LOCATION NO. 2  
McIVER ROAD WEST OF MANCHESTER LANE

GENERAL DESCRIPTION

This site is a rural two-lane gravel section of McIver Road just west of the Manchester Lane intersection. This site includes the crest of a hill on the east, and a reverse curve on the west.

EVALUATION

Traffic Volumes

This site has the lowest traffic volumes of any location observed in the study area. The 1989 two-way ADT is approximately 400 vehicles.

Signing

The "S" curve is properly signed in both directions of travel. However, no supplementary speed plates are posted with the curve signs. There is no delineation throughout the site. There are several rural type mailboxes located near Sta. 0+00 just east of the "S" curves very close to the roadway edge.

Accidents

Two accidents occurred at this location throughout the study period. Both occurred during clear weather, dry roadway conditions at night. One vehicle left the roadway and over-turned down an embankment along the north side of the roadway. The other accident vehicle lost control while failing to negotiate the second or "east" curve while traveling eastbound. One accident occurred on a Friday night and alcohol involvement was noted on the accident report.

Contributing Factors

Factors contributing to the accidents at this location are:

- Inadequate sight distance over the crest vertical curve located east of the "S" curves;
- Loose Material on the gravel roadway;
- Alcohol involvement;
- Speed too fast for conditions.

Westbound drivers even if familiar with the site are confronted by the setting sun while passing over the crest vertical curve. Westbound drivers unfamiliar with the site are confronted by an "S" curve immediately beyond the crest vertical curve. Inattentive drivers may be surprised by the roadway alignment throughout the site. The gravelly nature of the roadway lends itself to vehicles losing control.

## RECOMMENDED IMPROVEMENTS - McIVER ROAD WEST OF MANCHESTER LANE

### Short Term

The following short term improvements are recommended to improve the safety of this location:

- Install Design "A", "C" and "D" delineators throughout the site;
- Replace the existing W1-4 curve signs with W1-3 reverse turn signs and add W13-1 30 MPH advisory speed plates.
- Install R2-1 35 mph speed limit signs for westbound travel in advance of the crest vertical curve and for eastbound travel in advance of the reverse curves.
- Install new R2-5a Reduce Speed Ahead sign for eastbound traffic west of the new 35 mph speed limit sign.
- Relocate mailboxes to a common site off McIver Road to current standards.
- Improve the edge drop off beyond the gravel edge onto the adjacent shoulder.

The preliminary cost estimate for the improvements at this site is \$8,610. Of this cost, approximately \$730 is eligible for FHWA funding.

### Long-Term

There are no long term improvements recommended at this location.

# ACCIDENT DATA

SITE NUMBER 2

ACCIDENT PERIOD 1986-1988

		86	87	88
		1	1	

## NUMBER OF ACCIDENTS BY MONTH

JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
						1			1		

## NUMBER OF ACCIDENTS BY DAY OF WEEK

SUN	MON	TUES	WED	THURS	FRI	SAT
		1			1	

## NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

CLEAR	RAINING	SNOWING	FOG	OTHER
2				

## NUMBER OF ACCIDENTS BY ROAD CONDITIONS

DRY	WET	SNOWY	ICY	OTHER
2				

## NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

DAYLIGHT	DARK OR DUSK	DARK, LIGHTED	DARK, UNLIGHTED
			2

## NUMBER OF ACCIDENTS BY ACCIDENT TYPE

ANGLE	R-END	FX-OBJ	PED	BACKING	SIDWYP	NON-COL	HEAD-ON	LIVESTOCK
		1				1		

## NUMBER OF ACCIDENTS BY NUMBER OF INJURIES

0	1	2	3	4	5
1	1				

## NUMBER OF ACCIDENTS BY NUMBER OF FATALITIES

0	1	2	3	4	5
2					

YEARLY SUMMARY OF NUMBER OF INJURIES, NUMBER OF FATALITIES, AND NUMBER OF PROPERTY DAMAGE ONLY

	86	87	88
No. inj.		1	
No. fatal.			
No. P.D.O.		1	

RECOMMENDED PROGRAM  
WITH SIGHT DISTANCE INDICATOR  
CASCADE COUNTY, MONTANA  
DETERMINATION OF PRIORITY INDEX

Site Number 2

Site Description McIver Road West of Manchester Lane

PRIORITY INDEX FOR SHORT TERM IMPROVEMENTS (S.P.I.)

From Table 6:

S.P.I. = H.I. = 49.45

PRIORITY INDEX FOR LONG TERM IMPROVEMENTS (L.P.I.)

Benefit-Cost Ratio = 0.72

B/C Index Value = 0

L.P.I. =  $0.75 \times (\text{H.I.}) + 0.25 \times (\text{B/C.I.})$

=  $0.75 \times \underline{49.45} + 0.25 \times \underline{0}$

L.P.I. = 37.09

Form for Determination of Priority Index





SITE 2: Taken near the PC of the south westbound curve to the right from a gravel driveway approach looking northwest. (4/24)



SITE 2: Taken on McIver Road approximately midway through the south curve looking northwest. (5/3)







SITE 2: Taken on McIver Road at the PC of the north curve to the left looking southeast. (5/9)



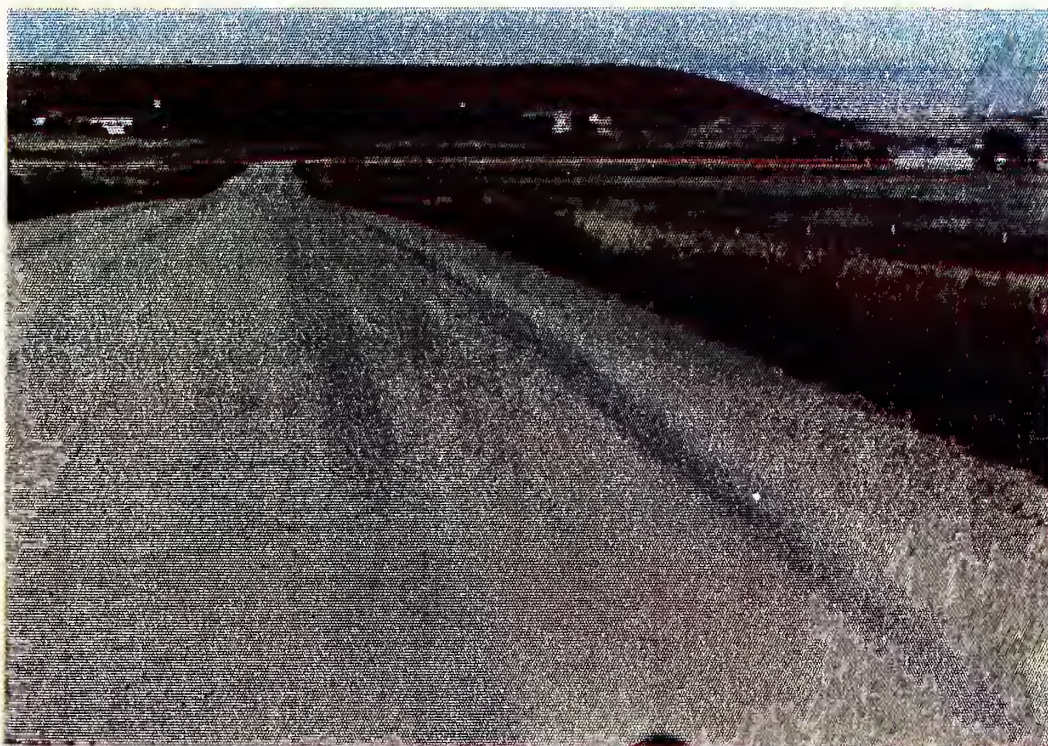
SITE 2: Taken on McIver Road at the PC of the north curve looking south. (5/7)







SITE 2: On McIver Road just west of the crest vertical curve looking east at the crest vertical curve. (5/12)



SITE 2: On the crest vertical curve of McIver Road looking west. (5/13)









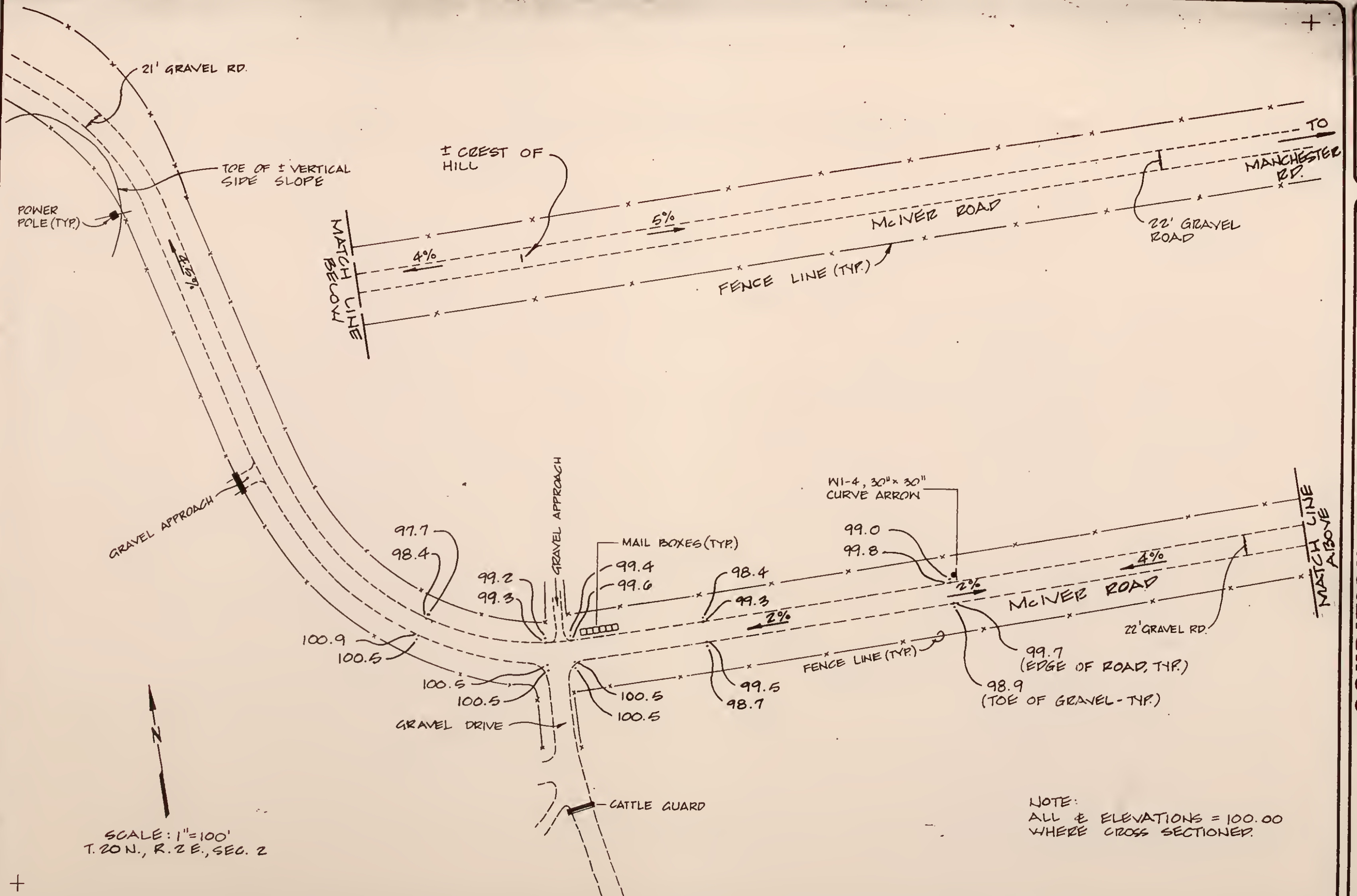
SITE 2: On McIver Road near the east base of the crest vertical curve looking west. (5/15)



SITE 2: Station 0+00 at approximately 200' south of McIver Road looking north. (5/16)







NOTE:  
ALL ELEVATIONS = 100.00  
WHERE CROSS SECTIONED.

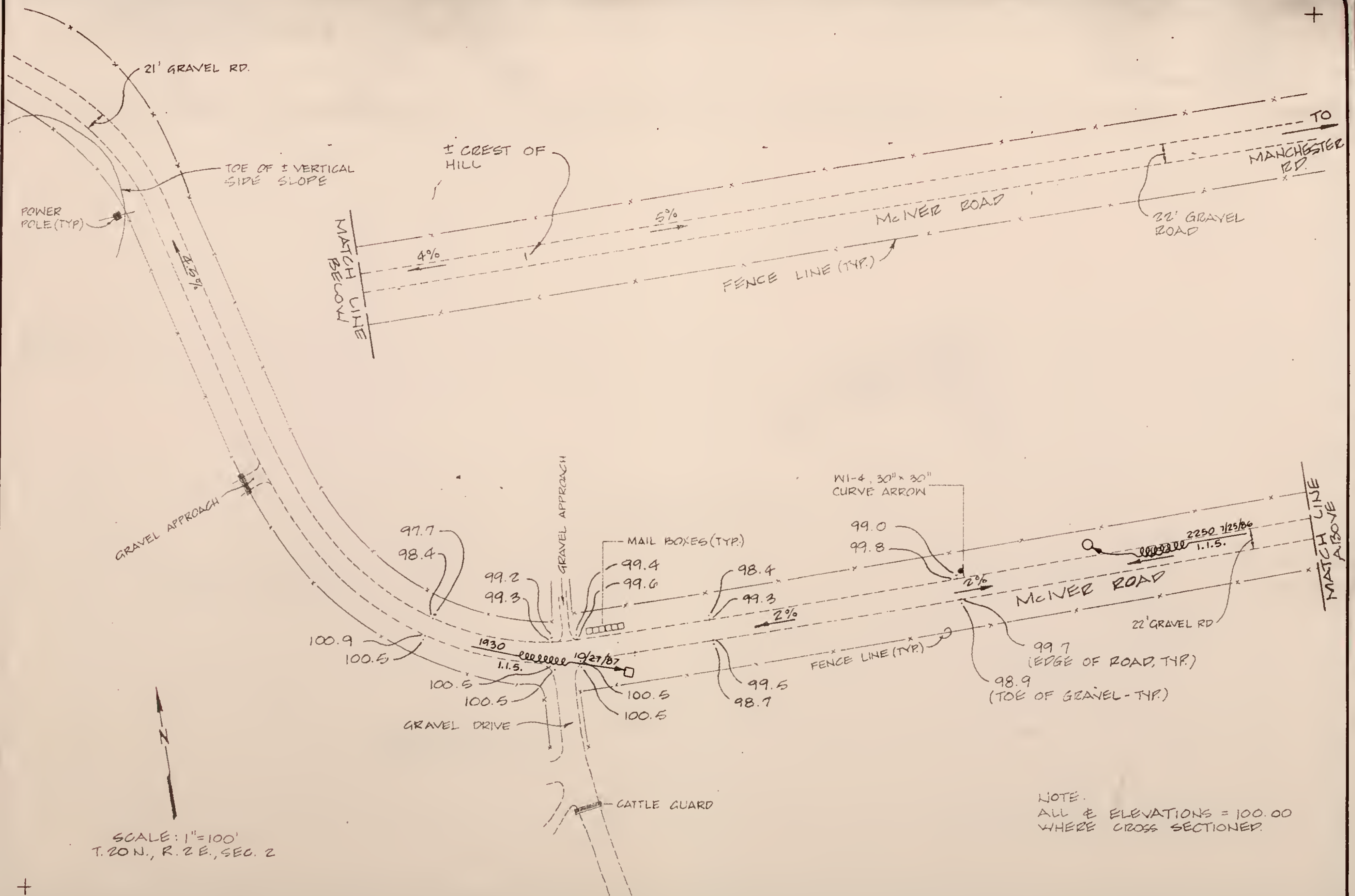
# **CONDITION DIAGRAM** MCIVER RD. 3-.6 MI. WEST OF MANCHESTER INTERSECTION

SITE 2

HKA ASSOCIATES  
ENGINEERS - PLANNERS  
20144.103 SEPT., 1960







# **ACCIDENT DIAGRAM** **McIVER RD. 3-.6 MI. WEST** **OF MANCHESTER INTERSECTION**









LOCATION NO. 3  
GIBSON FLATS ROAD AND 26th ST. SOUTH INTERSECTION

GENERAL DESCRIPTION

This is a rural four legged intersection in the southeast quadrant of the Great Falls urban area. All legs are paved except for the south leg of the intersection. All paved legs of the intersection are striped for no passing within 400 feet of the site. From this intersection the terrain rises to the west and north. The northeast quadrant of the intersection has been enlarged and 26 feet of pavement provided for an exclusive westbound right turn only lane. A gravel median results in the northeast corner of the site.

EVALUATION

Traffic Volumes

Gibson Flats Road or 33rd Ave. South is the predominant traffic volume street with a 1989 two-way ADT of approximately 670 vehicles per day. 26th St. South carries approximately 560 vehicles per day based on field observations for this study. Most 26th St. South traffic uses the north approach, reflected in the gravel nature of 26th St. South of the site.

Signing

All four legs of the intersection contain a W2-1 cross road sign in advance of the site. The speed limits for vehicles entering from all four directions is 40 MPH. There are also 40 MPH speed limit signs posted for northbound, eastbound and westbound traffic away from the intersection. There are street name signs in the proximity of the intersection. There is no delineation through the site. There is an R5-1 Do Not Enter sign for southbound to eastbound traffic in the northeast quadrant of the intersection just north of the gravel median.

Accidents

Five accidents occurred at this location throughout the study period. Only one occurred during icy roadway conditions. Most were during darkness or dusk light conditions. Three of the accidents occurred during Friday or Saturday. Alcohol was cited as a possible contributing factor on two accidents. Most accidents were of the single vehicle non-collision type however, one angle accident did occur in 1987.

Contributing Factors

The contributing factors to accidents at this location are:

- Alcohol involvement;

- Loose material on the roadway;
- Inadequate sight distance;
- Other crimes leading to high speeds;  
(Hit and run accident in 1986)  
(Stolen vehicle in 1988)

# RECOMMENDED IMPROVEMENTS - GIBSON FLATS ROAD/33rd AVENUE SOUTH & 26th ST. SOUTH

## Short Term

The following short term improvements are recommended to improve the safety of this location.

- Add W13-1 30 MPH Advisory speed plate to the existing eastbound cross road sign on Gibson Flats Road;
- Add W13-1 20 MPH Advisory speed plate to the southbound crossroad sign on 26th St. S.;
- Remove the outer 5 foot edge of paving throughout the curve, and install a new R1-2 yield sign for westbound to northbound right turns. Delineate the gravel median, and the outside edge of the resulting right turn only lane. Install "↑ Only" pavement marking for the westbound right turn near enough to 26th St. S. to be seen by southbound vehicles.

Currently this paved area is 26 feet wide which attracts both southbound left turns and westbound right turns. Due to the slope and radius of the curve, sight distance is restricted for two-way operation. The location is signed with a Do Not Enter sign for the southbound left turns which has only a 44% observance rate. Along with narrowing up this outer curve, provide delineation treatment as shown on the recommended improvement diagram. Additionally, provide 4" wide edge striping throughout the right turn maneuver and within 300 feet of the intersection.

- Extend existing 4" double yellow striping on 26th St. South further south to near the north edge of Gibson Flats Road.
- Remove existing R5-1 Do Not Enter sign from the NE quadrant of the intersection.
- Replace sign faces on all (3) R12-5 Load Limit signs leading away from the site.

The preliminary cost estimate for the improvements at this site is \$2,570. Of this cost, approximately \$990 is eligible for FHWA funding.

Long Term (No Diagram)

The following long term improvements are recommended to improve the safety of this location:

- Improve the site distance along the north leg of 26th St. S by removing the crest vertical curve in close proximity to the intersection;
- Add Stop sign control to southbound 26th St. S upon completion of a Stop Sign Warrant Study with current traffic data for the time frame involved.

The preliminary cost estimate for the improvements at this site is \$52,940. Of this cost, approximately \$480 is eligible for FHWA funding.



# ACCIDENT DATA

SITE NUMBER 3

ACCIDENT PERIOD 1986-1988

		86	87	88
		1	1	3

## NUMBER OF ACCIDENTS BY MONTH

JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
			1	1			1			1	1

## NUMBER OF ACCIDENTS BY DAY OF WEEK

SUN	MON	TUES	WED	THURS	FRI	SAT
	1		1		2	1

## NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

CLEAR	RAINING	SNOWING	FOG	OTHER
4				1

## NUMBER OF ACCIDENTS BY ROAD CONDITIONS

DRY	WET	SNOWY	ICY	OTHER
4			1	

## NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

DAYLIGHT	DARK OR DUSK	DARK, LIGHTED	DARK, UNLIGHTED
1	2		2

## NUMBER OF ACCIDENTS BY ACCIDENT TYPE

ANGLE	R-END	FX-OBJ	PED	BACKING	SIDWYP	NON-COL	HEAD-ON	LIVESTOCK
1						4		

## NUMBER OF ACCIDENTS BY NUMBER OF INJURIES

0	1	2	3	4	5
2	2			1	

## NUMBER OF ACCIDENTS BY NUMBER OF FATALITIES

0	1	2	3	4	5
5					

## YEARLY SUMMARY OF NUMBER OF INJURIES, NUMBER OF FATALITIES, AND NUMBER OF PROPERTY DAMAGE ONLY

		86	87	88
No. inj.		1	1	1
No. fatal.				
No. P.D.O.				2

RECOMMENDED PROGRAM  
WITH SIGHT DISTANCE INDICATOR  
CASCADE COUNTY, MONTANA  
DETERMINATION OF PRIORITY INDEX

Site Number 3  
Site Description Gibson Flats Road & 26th St. S. Intersection

PRIORITY INDEX FOR SHORT TERM IMPROVEMENTS (S.P.I.)

S.P.I. = H.I. = 58.97

PRIORITY INDEX FOR LONG TERM IMPROVEMENTS (L.P.I.)

From Table 6:

Benefit-Cost Ratio = 0.27

B/C Index Value = 0

L.P.I. =  $0.75 \times (\text{H.I.}) + 0.25 \times (\text{B/C.I.})$

=  $0.75 \times \underline{58.97} + 0.25 \times \underline{0}$

L.P.I. = 44.23

Form for Determination of Priority Index







SITE 3: From 26th St. S approximately 450' south of Gibson Flats Road looking north. The black sports car is in the right turn only lane in the northeast quadrant of the intersection. (1/1+2)



SITE 3: From Gibson Flats Road approximately .05 miles east of 26th St. S looking west. The speed limit sign is in the left foreground and there is a southbound to eastbound auto making the illegal left turn maneuver. This vehicle is turning the wrong way down the westbound to northbound right turn only lane. (1/5)









SITE 3: On 26th St. S looking south in advance of Gibson Flats Road from the approximate drivers eye position. Note the disappearance of the vehicle over the crest of the hill in advance of Gibson Flats Road. (1/6)



SITE 3: From 26th St. S approximately 200' north of the intersection with Gibson Flats Road looking south. (1/8)









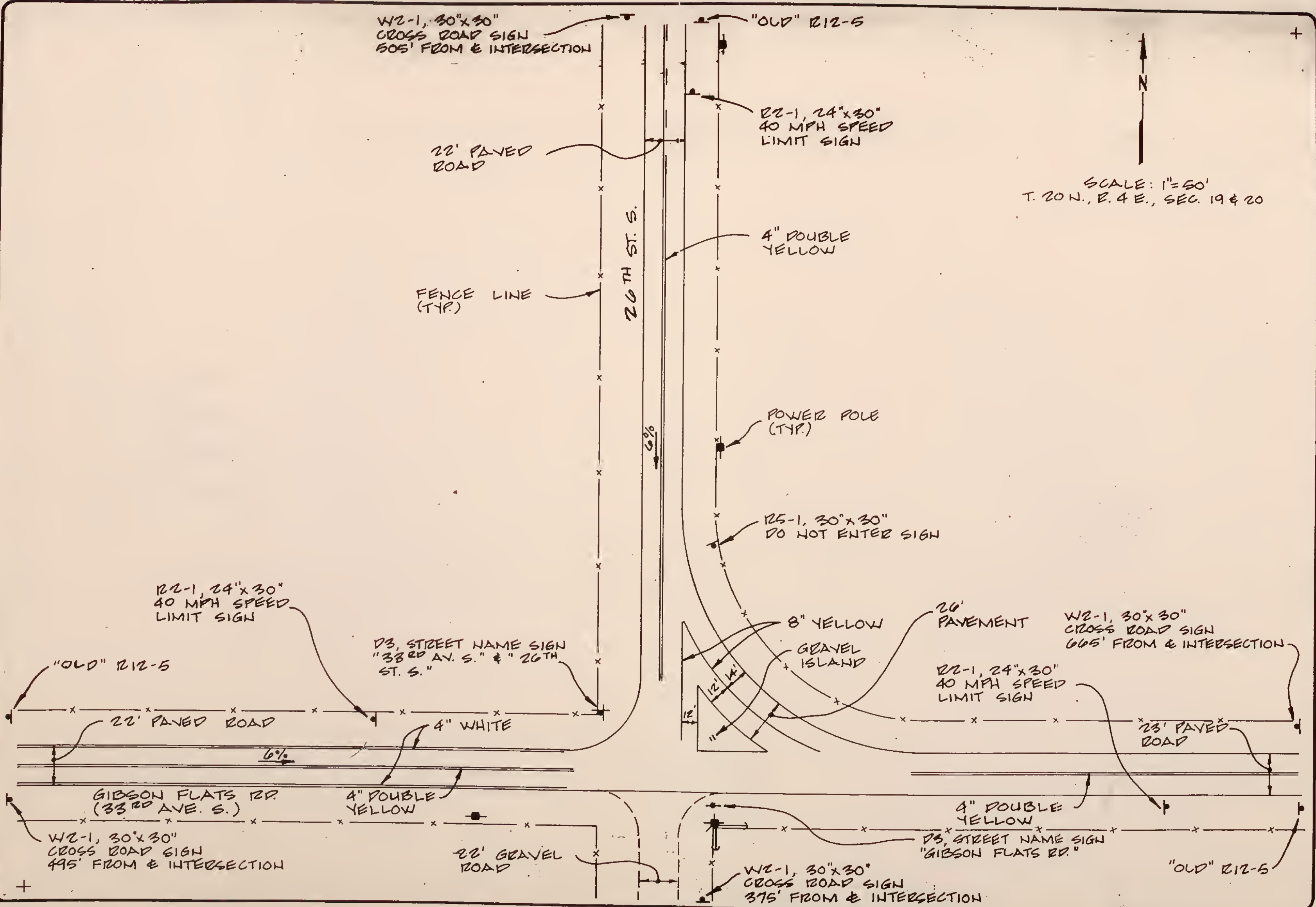
SITE 3: On Gibson Flats Road at approximately 0.1 miles west of the intersection with 26th St. S looking east. (1/10)



SITE 3: Taken on Gibson Flats Road approximately 400' west of 26th St. S (adjacent to the intersection ahead sign) looking east. (1/11)





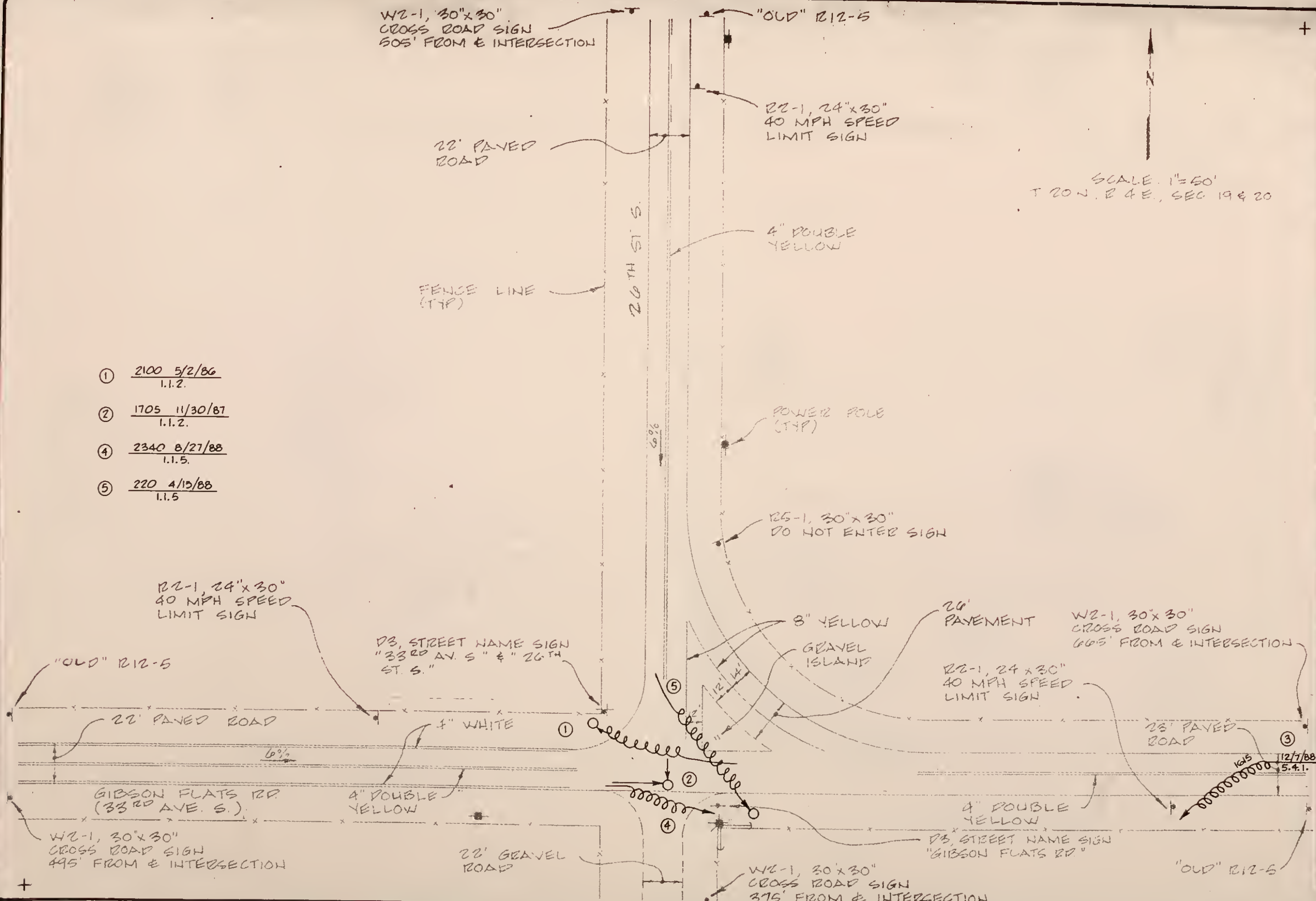






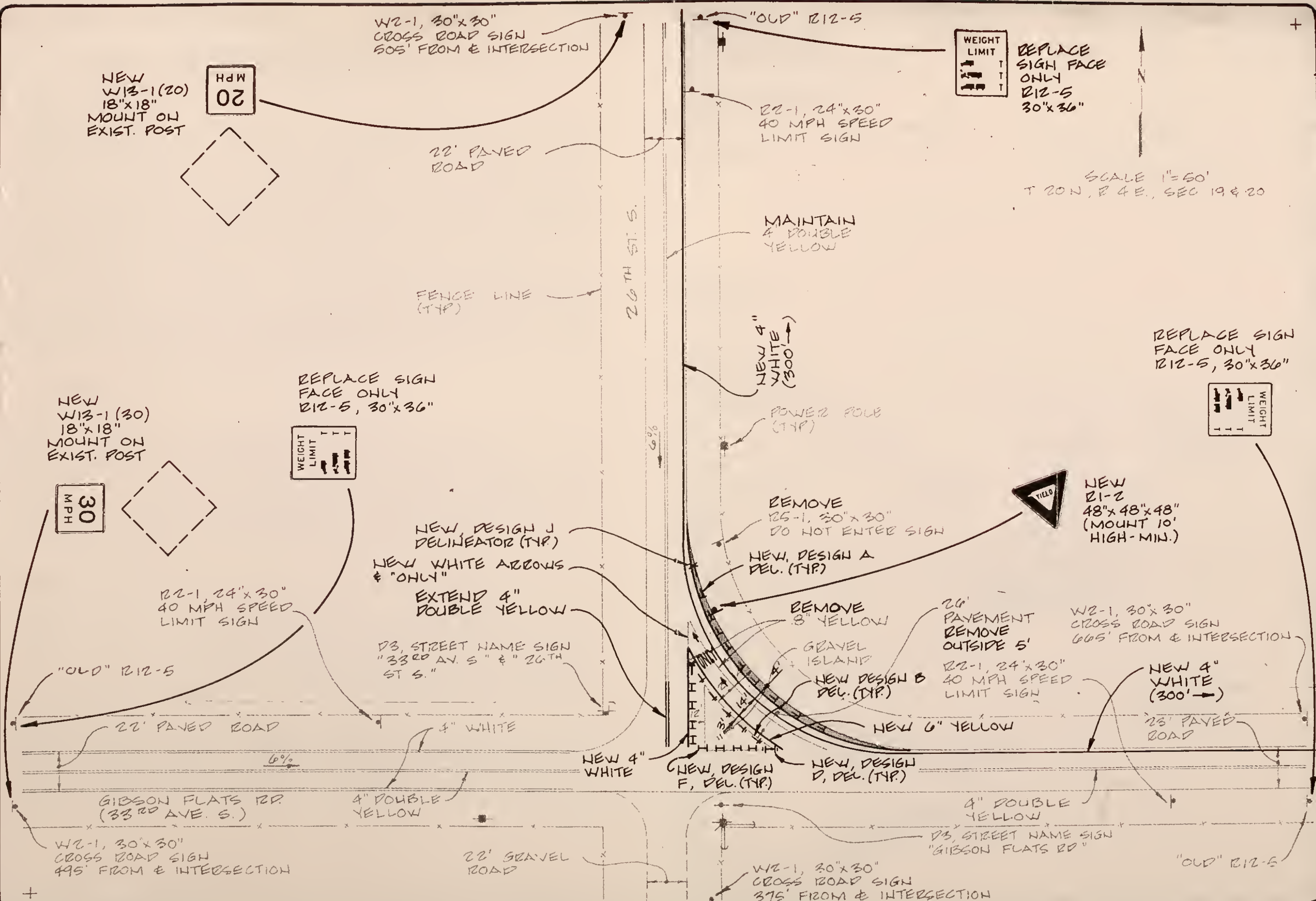
**ACCIDENT DIAGRAM**

**GIBSON FLATS RD. & 26th ST. SOUTH INTERSECTION**



- ① 2100 5/2/86  
I.I.2.
- ② 1705 11/30/87  
I.I.2.
- ④ 2340 8/27/88  
I.I.5.
- ⑤ 220 4/15/88  
I.I.5









LOCATION NO. 4  
LOWER RIVER ROAD & TRAILER TERRACE/55th AVE. S  
(EAST WILSON BUTTE ROAD WEST)

GENERAL DESCRIPTION .

This site is a rural, paved, two way-two lane intersection location near the south urban boundary of Great Falls. The site is considered an intersection location, however it is located at the base of a 6% hill rising to the south which may be a factor in the hazardousness of this location. Alternatively the intersection may be a contributing factor to the accidents which take place just south of the intersection. Land use to the west and south is rural residential or agricultural. There are trailer courts located adjacent to the site on the northeast and southeast quadrant of the intersection. Lower River Road is designated State Secondary 226. Trailer Terrace/56th Avenue S is also designated State Secondary 459. There are grass medians in all four quadrants of this intersection. A convenience store is located in the northeast corner of the intersection approximately 400 feet north of the intersection PI.

EVALUATION

Traffic Volumes

Based on field observations between 8:00 and 9:00 A.M., Lower River Road experiences light traffic volume. However, at the base of the hill at the intersection site, there is significant cross traffic, school bus stops, and left turning conflicts at the site especially in the north leg of the intersection. Lower River Road is the predominant traffic volume street at this site. Nearly 1700 vehicles enter this site from all legs on a daily basis.

Signing

Speed Limits. The posted speed limit on Trailer Terrace/55th Ave. S is 35 MPH in both directions on both legs. The posted speed limit for southbound traffic north of the site is 45 MPH. The speed limit is unposted for northbound traffic south of the site. The first speed restriction for northbound traffic occurs approximately 400 feet north of the intersection just north of the convenience store.

Right-of-Way Traffic Control. R1-1 Stop signs are posted at all eastbound and westbound intersections with Lower River Road. However, no Stop or Yield signs are posted on any of the turning lanes leading away from Lower River Road where they merge into 55th Ave. S or Wilson Butte Road.

Other Signing. D-3 street signs are posted in the southeast and northwest quadrants of the intersection. However, all street names of the three legs change their name designations at this site. Lower River Road is known as Eden Road to the south, 55th Ave. S is known as Trailer Terrace to the east, and Wilson Butte Road to the west. Design "D" delineators are in place at some locations as noted on the condition diagram. State secondary junction signing does exist for northbound and southbound traffic in advance of the site. There is an R3-1 Stop Ahead sign for westbound 55th Ave. S, and a W2-1 cross road sign for southbound Lower River Road traffic.

Pavement Markings. Throughout the site and on the hill south of the intersection all road hills are striped with solid double yellow centerline stripes. Immediately north of this intersection is the beginning northbound passing zone. Immediately east of the intersection is the beginning of a eastbound passing zone. All right turn lanes of the intersection created by the medians are striped for two way traffic except in the southeast quadrant. It is interesting to note that although striped for two way traffic, the width of the eastbound to southbound right turn lane is only 12 feet total.

## ACCIDENTS

Two accidents occurred at this location throughout the study period. One accident occurred during clear dry roadway conditions at night, the other accident occurred during the daylight hours in a snow storm on icy roadway conditions. Both accidents were fixed object type accidents, one resulting in two injuries.

## Contributing Factors

Major factors contributing to the accidents at this location are:

- Mechanical defect (brakes);
- Inattentive driving;
- Speed too fast for conditions;
- Driver inexperience;
- Careless driving.

It is interesting to note both accidents occurred on the south leg of the intersection. It is also interesting to note that the rating team ranked this location fairly poor in both the information systems and driver expectancy categories. All legs of the intersection were driven with a ball bank indicator to determine safe driving speeds results of the ball bank indicator speed checks are as follows:

<u>FROM</u>	<u>TO</u>	<u>SPEED</u>
South	East	25 MPH
East	North	30 MPH
North	West	25 MPH
West	South	Stop Sign
South	North (main line)	55 MPH

## RECOMMENDED IMPROVEMENTS

### Short Term

The following improvements are recommended to improve the safety of this location:

- Remove the double yellow centerline stripe from the southwest quadrant of the intersection;
- Extend the double yellow centerline stripes closer to the intersection PI, and install new edge stripes on all legs;
- Install new stop bars at the vehicle stop location at all Stop sign controlled locations;
- Install consistent design "D" delineators at the noses of all grass islands;
- Install R1-2 Yield sign for the northbound to eastbound right turn movement;
- Install R1-2 Yield sign for the southbound to eastbound right turn movement;
- Remove the pine trees to the southwest quadrant to the intersection on the inside of the Wilson Butte Road curve to allow for 450 feet of sight distance in advance of the intersection;
- Replace the vandalized M2-1 junction sign on the north leg of the intersection.
- Install R1-2 Yield sign for eastbound thru movement on the east leg of the intersection.
- Install new R1-1 Stop sign for eastbound traffic and replace R1-1 stop sign face for westbound traffic.
- Replace old R12-5 sign face on the east leg of the intersection.
- Relocate existing rural mailboxes to a common site away from the intersection to current MDOH standards.
- Add R1-1 Stop signs for the side approaches to Eden Road south of Trailer Terrace as shown in the diagram.
- Add a new W2-2 "Tee Intersection", new W7-1 "Hill", and new W7-26 lower gear supplemental speed plate 500' south of the crest of the hill, and at least 500' south of Eden Road for northbound traffic.
- Install design F type delineators throughout the curve south of the intersection.

The preliminary cost estimate for the improvements at this site is \$9,920. Of this costs, approximately \$1,730 is eligible for FHWA funding.

### Long Term

Remove the eastbound to southbound pavement and signing.

- Reclaim landscape and reseed this quadrant of the intersection, and reset the R1-1 Stop sign for eastbound thru traffic.
- Remove gravel, landscape and reseed allowing no wider than a 40 feet approach at the nearest approach to the intersection in the northeast quadrant.

The preliminary cost estimate for the improvements at this site is \$9,150. Of this costs, approximately \$140 is eligible for FHWA funding.



# ACCIDENT DATA

SITE NUMBER 4

ACCIDENT PERIOD 1986-1988

		86	87	88
		2		

## NUMBER OF ACCIDENTS BY MONTH

JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1			1								

## NUMBER OF ACCIDENTS BY DAY OF WEEK

SUN	MON	TUES	WED	THURS	FRI	SAT
1	1					

## NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

CLEAR	RAINING	SNOWING	FOG	OTHER
1		1		

## NUMBER OF ACCIDENTS BY ROAD CONDITIONS

DRY	WET	SNOWY	ICY	OTHER
1			1	

## NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

DAYLIGHT	DARK OR DUSK	DARK, LIGHTED	DARK, UNLIGHTED
1			1

## NUMBER OF ACCIDENTS BY ACCIDENT TYPE

ANGLE	R-END	FX-OBJ	PED	BACKING	SIDWYP	NON-COL	HEAD-ON	LIVESTOCK
		2						

## NUMBER OF ACCIDENTS BY NUMBER OF INJURIES

0	1	2	3	4	5
1		1			

## NUMBER OF ACCIDENTS BY NUMBER OF FATALITIES

0	1	2	3	4	5
2					

YEARLY SUMMARY OF NUMBER OF INJURIES, NUMBER OF FATALITIES,  
AND NUMBER OF PROPERTY DAMAGE ONLY

	86	87	88
No. inj.	2		
No. fatal.			
No. P.D.O.			

RECOMMENDED PROGRAM  
WITH SIGHT DISTANCE INDICATOR  
CASCADE COUNTY, MONTANA  
DETERMINATION OF PRIORITY INDEX

Site Number 4

Site Description Lower River Road & Trailer Terrace/55th Ave. S.

PRIORITY INDEX FOR SHORT TERM IMPROVEMENTS (S.P.I.)

From Table 6:

S.P.I. = H.I. = 52.20

PRIORITY INDEX FOR LONG TERM IMPROVEMENTS (L.P.I.)

Benefit-Cost Ratio = 0.38

B/C Index Value = 0

L.P.I. =  $0.75 \times (\text{H.I.}) + 0.25 \times (\text{B/C.I.})$

=  $0.75 \times \underline{52.20} + 0.25 \times \underline{0}$

L.P.I. = 39.15

Form for Determination of Priority Index





SITE 4: Approximately .25 miles south of Trailer Terrace on Lower River Road looking north. (3/15)

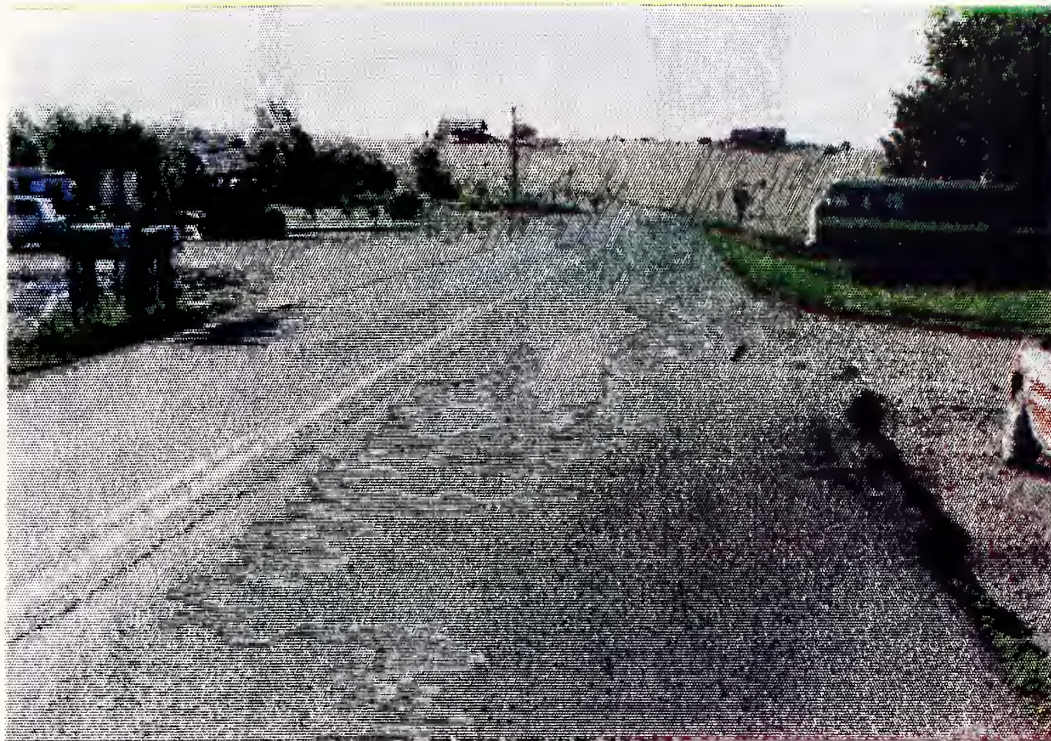


SITE 4: On Lower River Road 400' south of Trailer Terrace looking north. (3/18)









SITE 4: On Lower River Road at the first street approach north of Trailer Terrace looking south. (3/21)



SITE 4: From the northeast quadrant of the intersection, at the south convenience store drive approach on the east side of Lower River Road, looking southwest down Wilson Butte Road. (3/23)









SITE 4: On Wilson Butte Road from around the curve approximately 750' in advance of Lower River Road. Note the intersection is not visible from this location. (4/1)

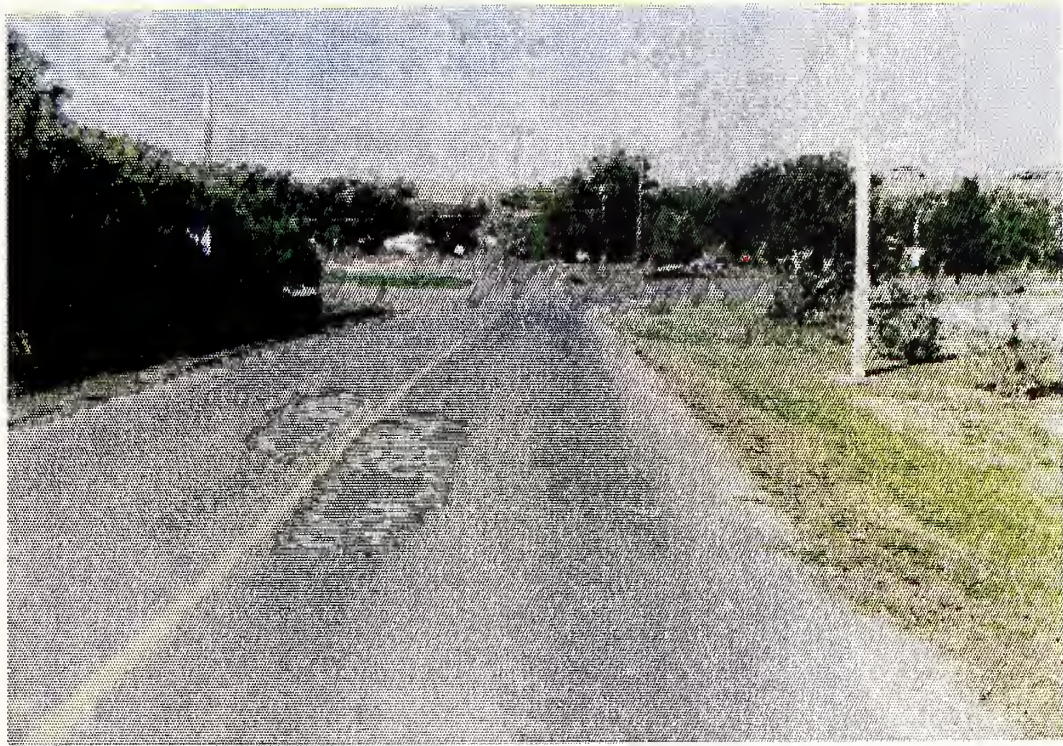


SITE 4: On Trailer Terrace approximately 750' east of Lower River Road looking west. Note the two pedestrians on the left side of the photo at the intersection. The W3-1a "Stop Sign Ahead" sign is faded. (4/2)





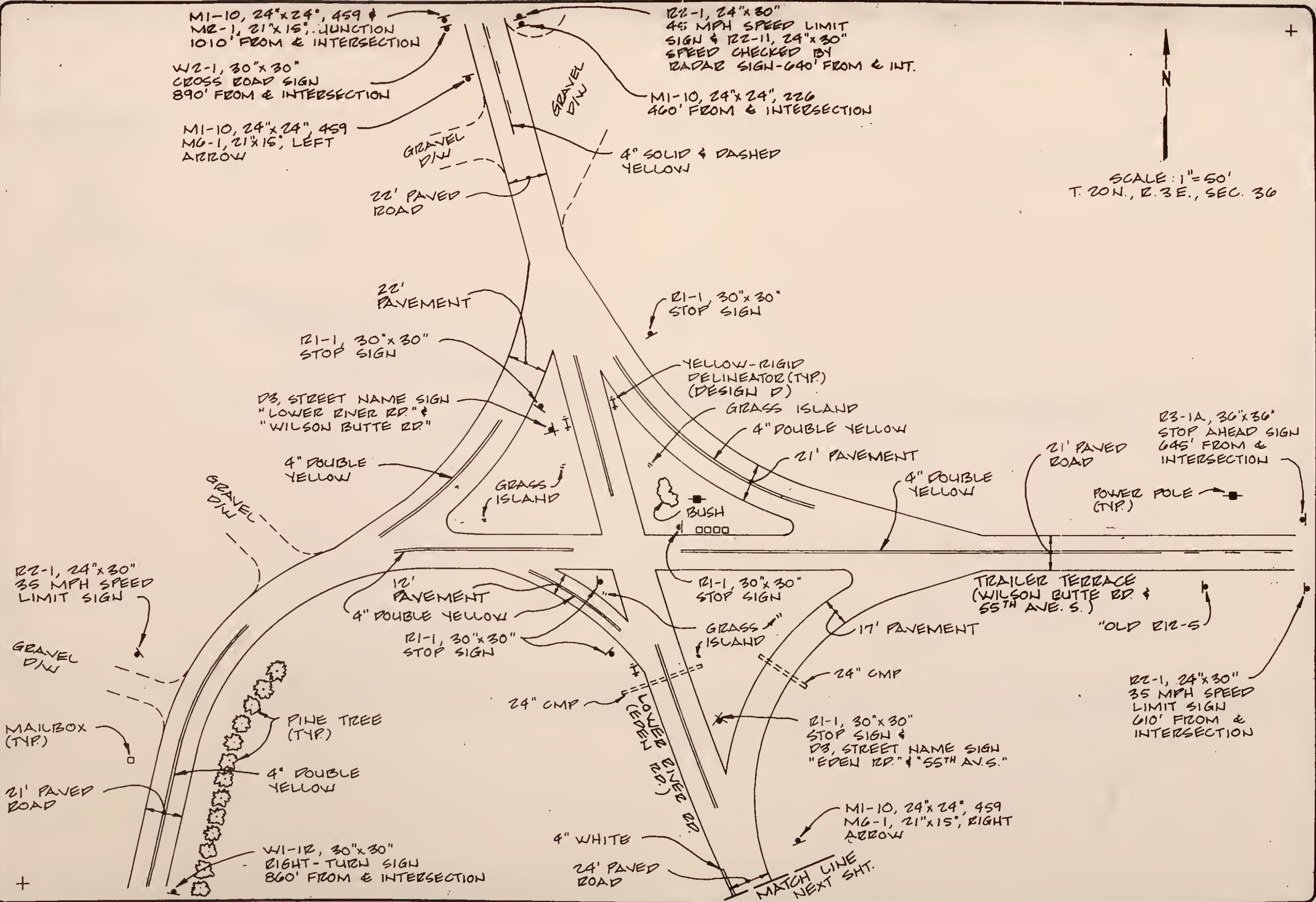




SITE 4: On Trailer Terrace approximately 400' east of Lower River Road looking west. Trailer Terrace slopes downward into the intersection at this location. (4/3)



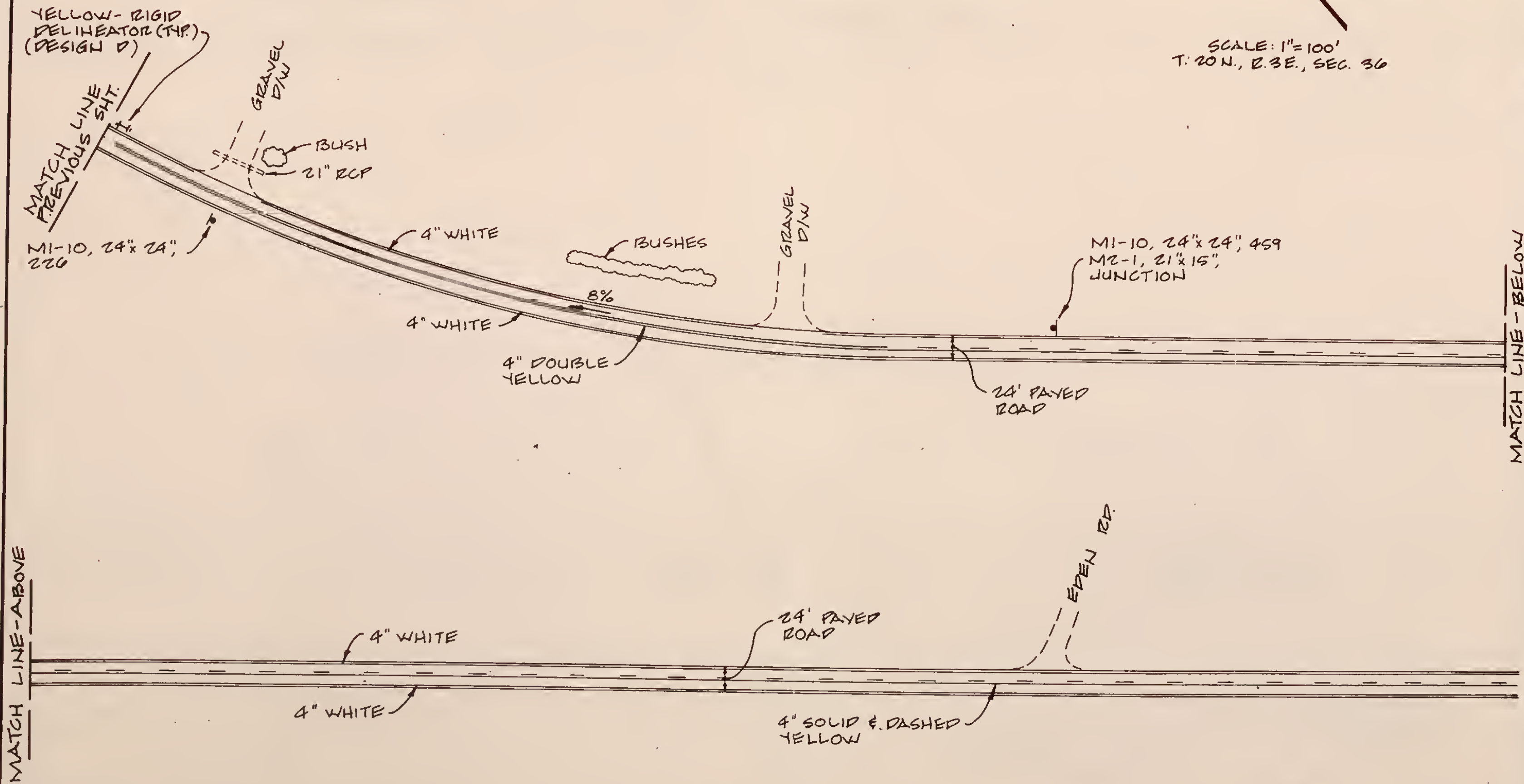




SCALE: 1"=50'  
T. 20N., R. 3E., SEC. 36







SCALE: 1"=100'  
T: 20 N., E. 3 E., SEC. 36

# CONDITION DIAGRAM

LOWER RIVER RD. & TRAILER TERRACE INTERSECTION

SITE 4

H&M ASSOCIATES  
ENGINEERS - PLANNERS  
2M144,103 SEPT., 1989









MATCH LINE-ABOVE

YELLOW-RIGID  
DELINTEATOR (THP)  
(DESIGN D)

MATCH LINE  
PREVIOUS SHT

M1-10, 24"x 24",  
226

GRAVEL  
D/W

BUSH  
21" RCP

310 4" WHITE  
4/20/86  
11.5

BUSHES

8%

4" WHITE

4" DOUBLE  
YELLOW

GRAVEL  
D/W

M1-10, 24"x 24", 459  
M2-1, 21"x 15",  
JUNCTION

24' PAVED  
ROAD

MATCH LINE-BELOW

4" WHITE

4" WHITE

24' PAVED  
ROAD

4" SOLID & DASHED  
YELLOW

EDEN RD.

SCALE: 1"=100'  
T. 20 N., R 3 E., SEC 36

SITE 4

HKA ASSOCIATES  
ENGINEERS - PLANNERS  
2M144.103 SEPT., 1989

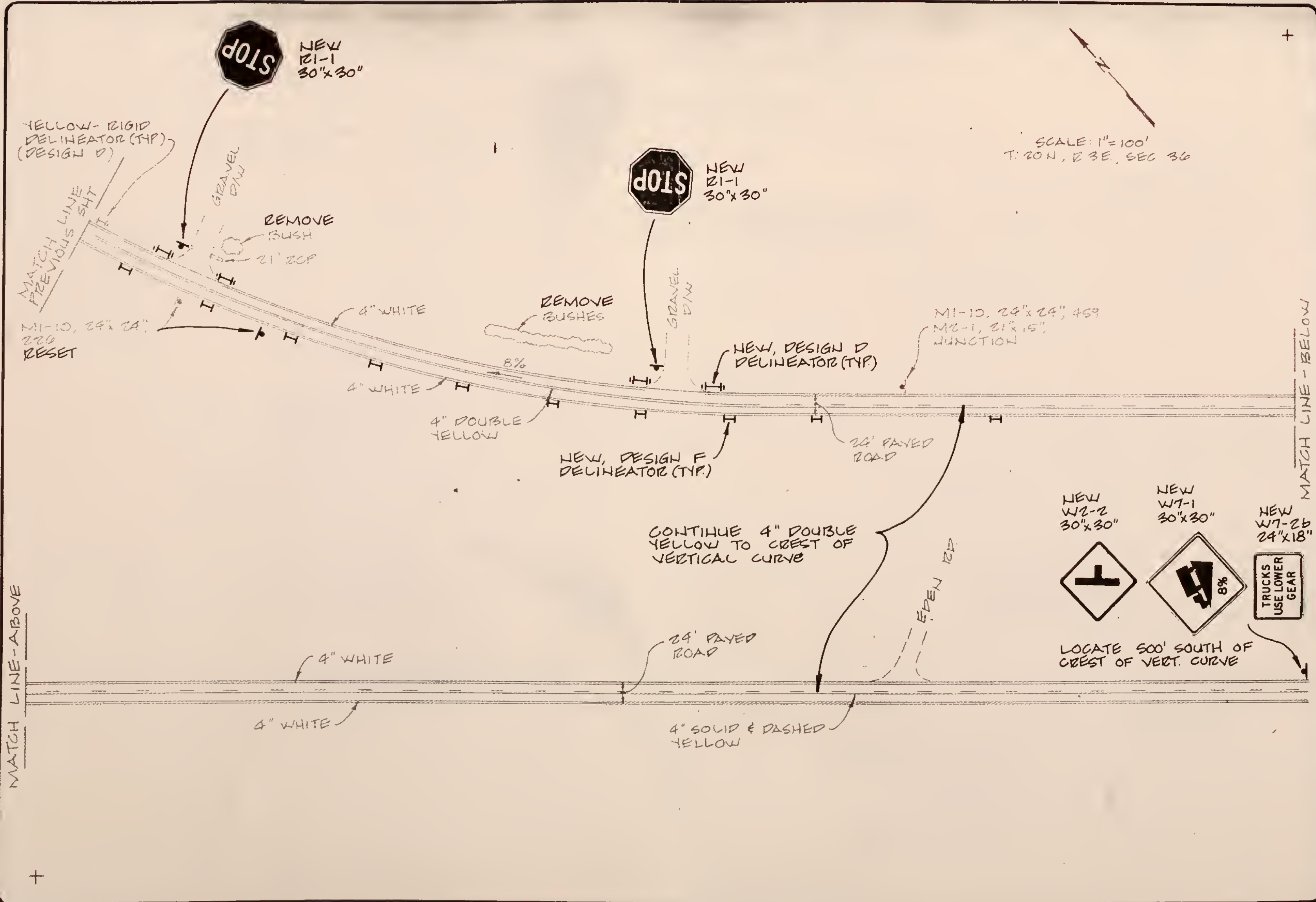
ACCIDENT DIAGRAM  
LOWER RIVER RD. & TRAILER TERRACE INTERSECTION







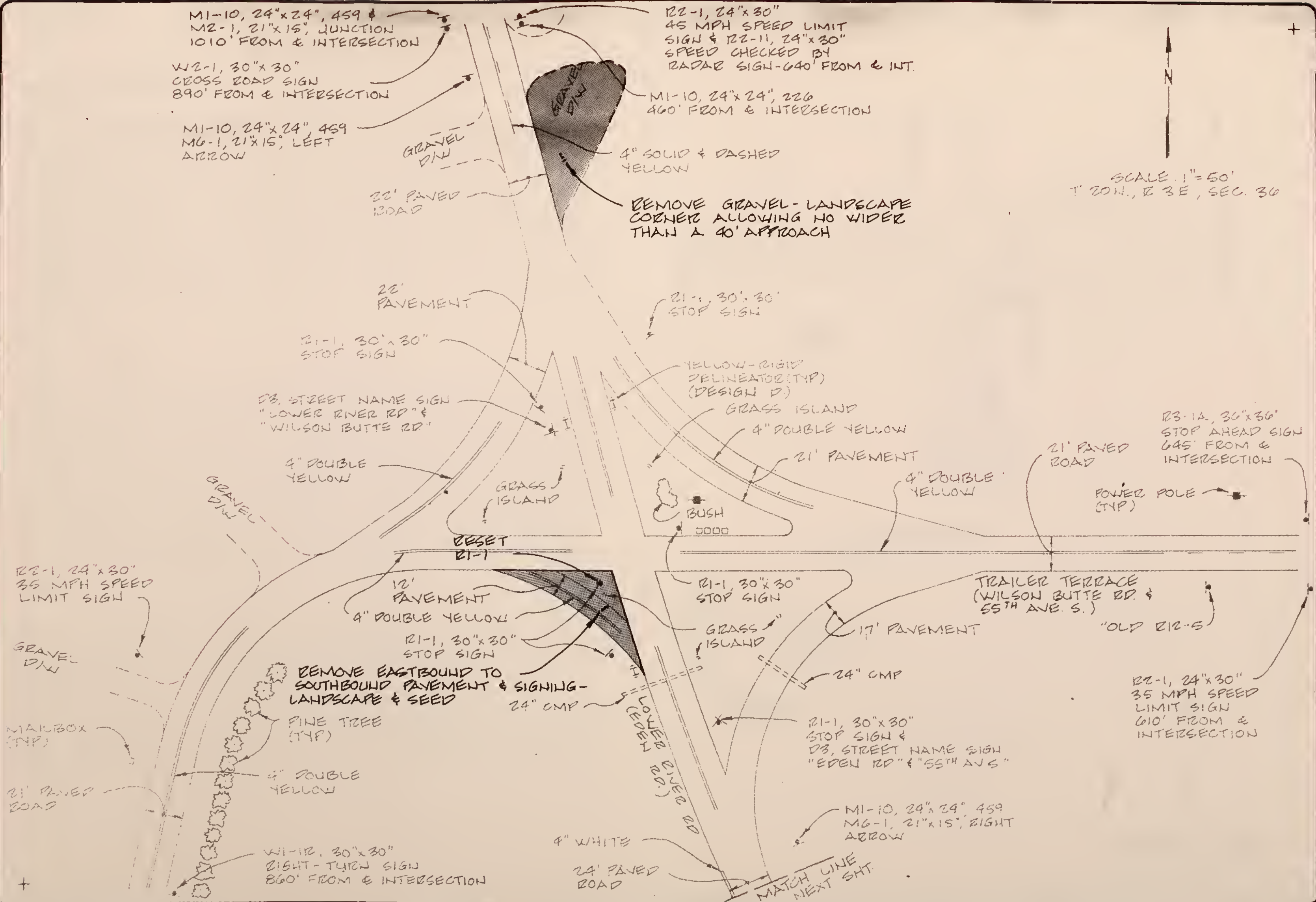




**RECOMMENDED IMPROVEMENTS (SHORT TERM)**  
 LOWER RIVER RD. & TRAILER TERRACE INTERSECTION











LOCATION NO. 5  
2nd AVE. N FROM 57th ST. TO 60th ST.

GENERAL DESCRIPTION

This is a urban non-intersection location along 2nd Avenue N, in the northeast quadrant of Great Falls. This site is a two-way, four lane arterial with raised curb medians. There are three left turn bay pockets in both directions of travel within the study area. Adjacent land use is residential and highway commercial in nature. Malmstrom Air Force Base's main entrance is located less than two-tenths of a mile east of the east site boundary. Second Avenue N is the principal arterial carrying traffic to and from the Air Force base. Trees and shrubs line both sides of the Avenue four to six feet off pavement edge at random locations. Breaks in the median are regularly spaced, however only one serves a through street at 58th St.

EVALUATION

Traffic Volumes

Traffic data for this site was available from City/County planning and City of Great Falls. 1988 counts in this location show a two-way ADT of 12,665 vehicles per day. Based on the historical data provided, the approximate 1989 traffic volume is 13,000 vehicles per day. Based on observations during the PM peak hour, traffic was heaviest westbound on 2nd Avenue N from 4:30 to 5:00 P.M. Considerable westbound left turn demand was observed at the nearby signal at 57th St. During the peak of the westbound demand, the signal cleared all but four or five westbound vehicles in each phase. At no time during the observation period did vehicles have to wait through more than one complete signal cycle. During the same timeframe there was only medium to light eastbound travel demand.

Signing

The site is signed for 45 MPH westbound traffic, and 45 MPH eastbound traffic until approximately 58th St. where speeds begin to reduce for entrance into Malmstrom Air Force Base. From approximately Sta. 14+00 to Sta. 18+50 the speed limit is 35 MPH and reduces to 25 MPH east of Sta. 18+50. The cross street at 58th St. is a "T" intersection with Stop sign control on the south leg. 58th St. is a 2 lane gravel roadway to the south. There are type "D" delineators on the end of most left turn pockets. 2nd Avenue N. is striped for passing throughout. There are no parking prohibitions throughout the site.

## Accidents

A total of fourteen accidents occurred at this site during the study period. The majority of accidents occurred during the fall or winter months on icy roadway conditions during periods of snow or overcast weather. Eight out of the fourteen accidents occurred during hours of twilight or darkness. Most accidents were either of the rear end or fixed object type, with only three accidents incurring any injuries.

It is interesting to note that of the 71% of the total accidents which occurred during icy roadway conditions, 60% involved westbound traffic, and 40% involved eastbound traffic. Most eastbound accidents occurred while slowing near the Air Force base, or due to left turn and cross traffic interference at the left turn bay pockets. Most westbound accidents during icy roadway conditions occurred in advance of the signal at 57th St.

## Contributing Factors

Major contributing factors to accidents at this location were:

- Icy roadway conditions;
- Queued eastbound vehicles into the Malmstrom Air Force Base entrance;
- Driver fatigue (fell asleep);
- Improper lane change;
- Inattentive driving;
- Improper U-turn;
- Improper lane change.

## RECOMMENDED IMPROVEMENTS - 2nd AVE. N FROM 57th ST. TO 60th ST.

### Short Term

The following short term improvements are recommended to improve the safety of this intersection:

- Colocate the rural type mailboxes especially in the vicinity of 58th St. to one central location off 2nd Avenue North;
- Improve winter time sanding/plowing of this location;
- Install new traffic signal heads on each leg of the intersection of 2nd Avenue North and 57th Street, capable of handling a protected/permissive left turn phase for each direction of travel.
- Install new D3 Street Name signs on the Stop sign post in the SE quadrant of the intersection of 2nd Avenue North and 57th Street.

During the study period involved and based on other conversations with the City of Great Falls, during the peak hour the westbound left turn demand does exceed the capacity of the left turn bay. This means left turning vehicles extend into through traveled way of 2nd Avenue N. On a short term basis, to clear the left turn bay without having through vehicles in motion, a protected/permissive leading green phase would allow the left turn bays to clear more vehicles. In addition, total intersection delay would decrease when operation changes from four-phase signal to a three-phase signal. A copy of the existing phasing diagram is attached

The preliminary cost estimate for the improvements at this site is \$6,500. Of this cost, approximately \$300 is eligible for FHWA funding.

#### Long Term

The following long term improvements are recommended to improve the safety of this intersection:

- Install a continuous two-way left turn lane from approximately Sta. 8+00 east to the Malmstrom Air Force Base entrance;
- Install new R3-9b continuous two-way left turn lane signing throughout as shown on the long term recommended improvement diagram;
- Further investigate the need for a dual ring 8 phase controller at the intersection of 57th St. to better accommodate the variable traffic demand at this location. The location of the intersection of 2nd Avenue North and 57th St. is just west of the study area boundary. However, based on traffic information provided by the City of Great Falls, 2nd Avenue North does experience better than a 70/30 directional traffic distribution. For this and other factors, further study is recommended to install a 8-phase controller;
- Install an advance signal change indicator on an overhead mast arm in advance of 57th St. for westbound traffic.

The preliminary cost estimate for the improvements at this site is \$103,600. Of this cost, approximately \$760 is eligible for FHWA funding.



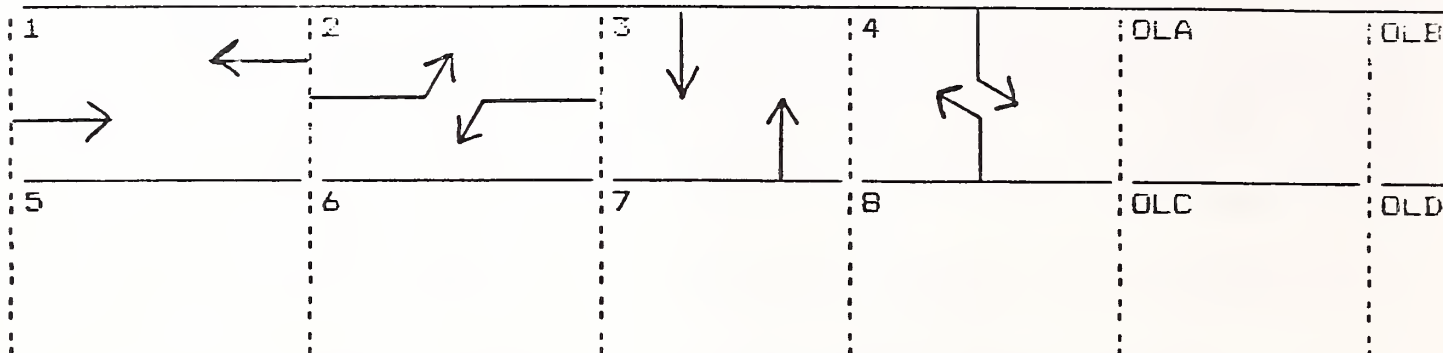
NORTH:



## INTERSECTION TIMING SHEET

INTERSECTION: 2ND. AVE. No. + 57<sup>th</sup> ST.DATE: 3-7-89FLASH PROGRAMING: NE R SE R EB R WB RSTATUS: Fully Act  
HP-40

PHASING DIAGRAM:



CONTROLLER PROGRAMING:

INTERVAL TIMING / PHASE	PHASES							
	1	2	3	4	5	6	7	8
MINIMUM GREEN	6	6	6	6				
INITIAL (IF USED)								
VEHICLE OR GAP	4	3	4	3				
WALK	11		10					
FLASHING DON'T WALK	12		11					
TOTAL PEDESTRIAN CLEARANCE	17		16					
VEHICLE CLEARANCE (AMBER)	4	3.5	4	3.5				
ALL RED CLEARANCE	1	1	1	1				
MAX. VEH. EXT. (IF USED)								
MAXIMUM PHASE GREEN	30	25	30	25				
MAXIMUM PHASE GREEN II								
ALL RED REVERT	2	2	2	2				
ACT. BEFORE ADDED INTIAL	1		1					
SECONDS / ACTUATION	0		0					
MAXIMUM INITIAL	6		6					
TIME BEFORE REDUCTION	8		8					
TIME TO REDUCE	10		10					
MINIMUM VEH. GAP	3		3					
RECALL OPTIONS (IF USED)								
VEHICLE DETECTOR MEMORY	L	NL	L	NL				

TIME CLOCK PROGRAMING:

FUNCTION OF CIRCUIT	CIRCUIT NUMBER	ON HOUR	OFF HOUR	ON HOUR	OFF HOUR	ON HOUR	OFF HOUR	ON HOUR	OFF HOUR
						SAT.	SAT.	SUN.	SUN.
AUTOMATIC FLASH	NONE								
COORDINATION	NONE								

# ACCIDENT DATA

SITE NUMBER 5

ACCIDENT PERIOD 1986-1988

		86	87	88
		5		9

## NUMBER OF ACCIDENTS BY MONTH

JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	1	2		1					2	4	3

## NUMBER OF ACCIDENTS BY DAY OF WEEK

SUN	MON	TUES	WED	THURS	FRI	SAT
	3		1	3	5	2

## NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

CLEAR	RAINING	SNOWING	FOG	OTHER
4	1	5		4

## NUMBER OF ACCIDENTS BY ROAD CONDITIONS

DRY	WET	SNOWY	ICY	OTHER
4			10	

## NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

DAYLIGHT	DARK OR DUSK	DARK, LIGHTED	DARK, UNLIGHTED
6	2		6

## NUMBER OF ACCIDENTS BY ACCIDENT TYPE

ANGLE	R-END	FX-OBJ	PED	BACKING	SIDWYP	NON-COL	HEAD-ON	LIVESTOCK
3	4	6			1			

## NUMBER OF ACCIDENTS BY NUMBER OF INJURIES

0	1	2	3	4	5
11	3				

## NUMBER OF ACCIDENTS BY NUMBER OF FATALITIES

0	1	2	3	4	5
14					

## YEARLY SUMMARY OF NUMBER OF INJURIES, NUMBER OF FATALITIES, AND NUMBER OF PROPERTY DAMAGE ONLY

	86	87	88
No. inj.	2		1
No. fatal.			
No. P.D.O.	3		8

RECOMMENDED PROGRAM  
WITH SIGHT DISTANCE INDICATOR  
CASCADE COUNTY, MONTANA  
DETERMINATION OF PRIORITY INDEX

Site Number 5  
Site Description 2nd Ave. N. from 57th St. to 60th St.

PRIORITY INDEX FOR SHORT TERM IMPROVEMENTS (S.P.I.)

From Table 6:

S.P.I. = H.I. = 24.98

PRIORITY INDEX FOR LONG TERM IMPROVEMENTS (L.P.I.)

Benefit-Cost Ratio = 0.12

B/C Index Value = 0

L.P.I. =  $0.75 \times (\text{H.I.}) + 0.25 \times (\text{B/C.I.})$

=  $0.75 \times \underline{24.98} + 0.25 \times \underline{0}$

L.P.I. = 18.74

Form for Determination of Priority Index





SITE 5: On 2nd Avenue North approximately 200' east of 58th Street North from the approximate driver eye height. The full signal indication is barely visible to westbound traffic from this location. (2/25)



SITE 5: On 58th Street approximately 110' south of 2nd Avenue looking north. Sight distance from the stop bar at 58th Street is good to the east. Sight distance to the west, is approximately 400' to the crest of the hill towards 57th Street. (3/1)





Fig. 1. The main entrance of the temple of the goddess Isis at Philae, Egypt. (After the drawing of the architect J. G. Thompson.)



Fig. 2. The main entrance of the temple of the goddess Isis at Philae, Egypt. (After the drawing of the architect J. G. Thompson.)





SITE 5: On 2nd Avenue North at the beginning of the first westbound left turn bay taper west of 58th Street looking west at 4:30 PM near the beginning of the peak hour. (3/2)



SITE 5: Taken from a gravel approach on the north side of 2nd Avenue North looking east from the approximate drivers eye position. Note the tops of westbound vehicles are just becoming visible. Time 4:41 PM. (3/7)









SITE 5: 2nd Avenue North just west of the end of the first break in the median west of 57th Street looking east. Time 5:00 PM. All westbound approach lanes clear on each cycle. (3/11)



SITE 5: Taken on 57th Street approximately 450' south of 2nd Avenue North looking north. Time 5:06 PM. 57th Street slopes down to the north. (3/13)









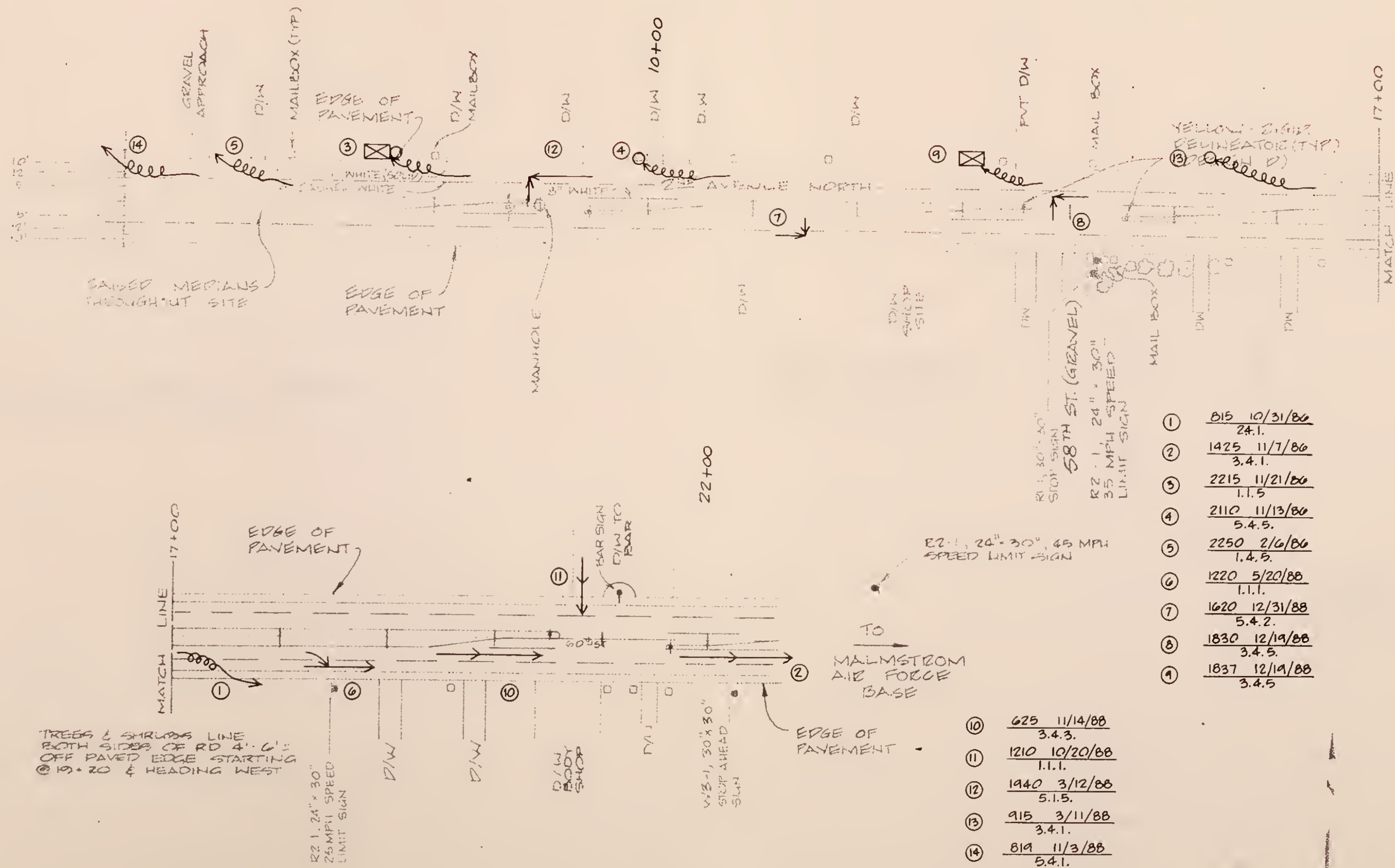
SITE 5: Taken on 57th Street approximately 500' north of 2nd Avenue  
North looking south. (3/14)











## ACCIDENT DIAGRAM

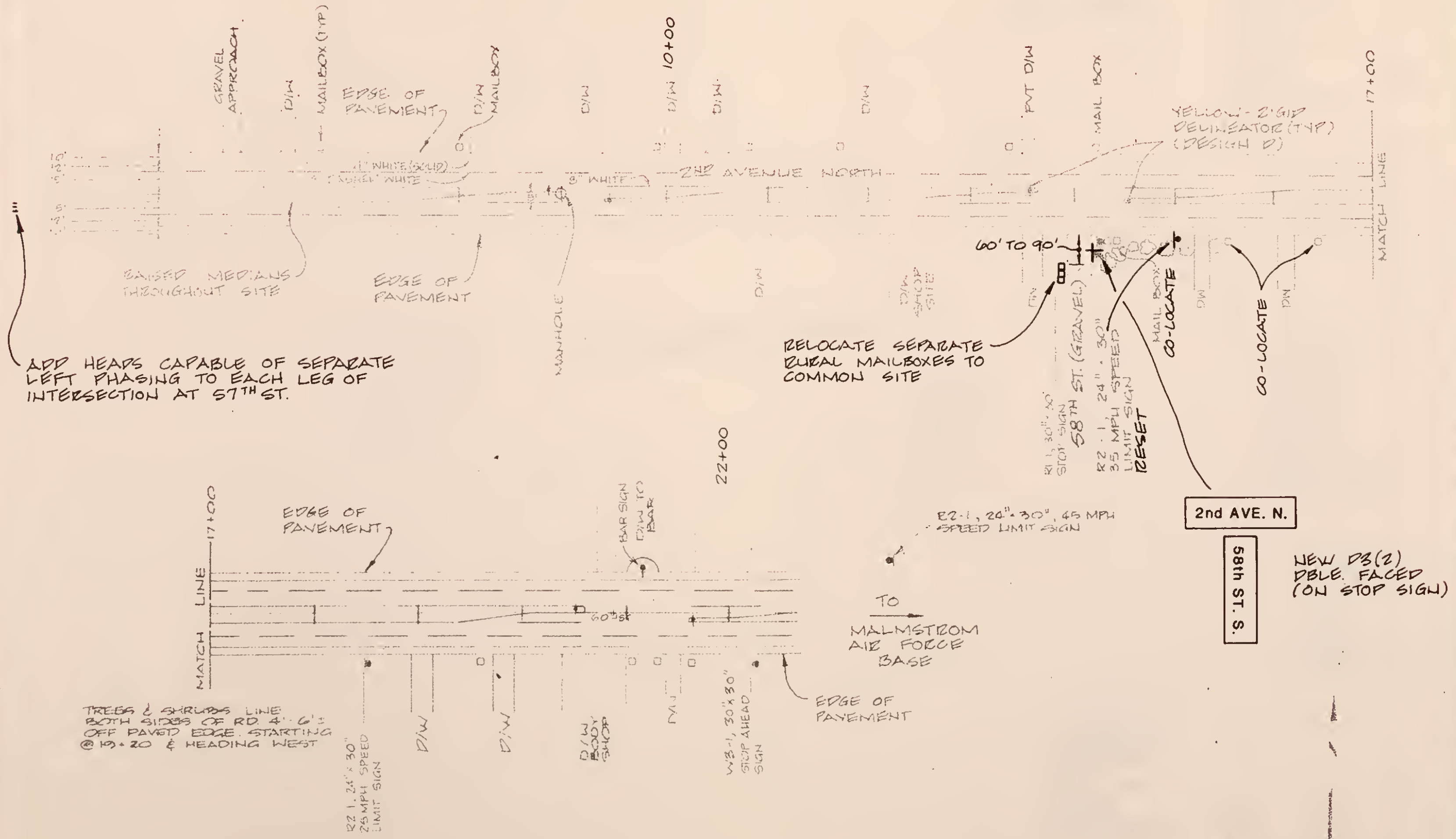
2nd AVE. N. FROM 57th ST. TO 60th ST.

SITE 5

HKA ASSOCIATES  
ENGINEERS - PLANNERS  
2M144.103 SEPT., 1989







ADD HEADS CAPABLE OF SEPARATE LEFT PHASING TO EACH LEG OF INTERSECTION AT 57TH ST.

TREES & SHRUBS LINE BOTH SIDES OF RD. 4'-6" OFF PAVED EDGE. STARTING @ 19+20 & HEADING WEST

R2-1, 24" x 30" 25 MPH SPEED LIMIT SIGN

D/W BODY SHOP

W3-1, 30" x 30" STOP AHEAD SIGN

TO MALMSTROM AIR FORCE BASE

R2-1, 24" x 30", 45 MPH SPEED LIMIT SIGN

2nd AVE. N.

58th ST S

NEW D3(2) DBLE. FACED (ON STOP SIGN)

SCALE 1" = 100'  
T20N R4E SEC 10

**RECOMMENDED IMPROVEMENTS(SHORT TERM)**  
2nd AVE. N. FROM 57th ST. TO 60th ST.

**SITE 5**  
**H&M ASSOCIATES**  
ENGINEERS - PLANNERS  
2M144.103 SEPT., 1989









LOCATION NO. 8  
13th STREET SOUTH & 24th AVENUE SOUTH

GENERAL DESCRIPTION

This is a rural, two way, "T" intersection near the south urban fringe of Great Falls. Residential land use borders the site to the west with residential and some commercial to the east. Land use is primarily agricultural in the southeast quadrant of the intersection. All legs of the intersection are paved.

EVALUATION

Traffic Volumes

13th St. S is the predominant traffic volume street at this location. On a daily basis over 2325 vehicles enter this site. There was a heavy southbound left turn and westbound right turn movement during the period observed.

Signing

Westbound traffic on 24th Ave. South is Stop sign controlled. There are centerline pavement marking on all 3 legs of the intersection. There are several rural type mailboxes throughout the project site.

Accidents

Two accidents occurred at this location during the study period. One was during icy roadway conditions at 3:00 P.M. in the afternoon and resulted in an angle type accident. The accident investigator was unable to determine if alcohol was a factor in the other accident which occurred at night. The driver left the scene of the accident before the investigator arrived. Both accidents reported at this location occurred in 1986.

Contributing Factors

Although the sight distance indicator at this location is not high, the intersection location is not very evident from 13th St. S. Northbound traffic approaching from the south drops out of the sight of following northbound traffic approximately .1 miles south of the intersection, and then reappears at the intersection location. The intersection location is difficult to distinguish for southbound vehicles due to the adjacent land use and vegetation.

Contributing Factors relating to the cause of accidents at this location were:

- Poor roadway condition (ice);

- Failure to observe the westbound Stop sign;
- Lack of conspicuousness of the intersection site.

## RECOMMENDED IMPROVEMENTS

### Short Term

The following short term improvements are recommended to improve the safety of this location:

- Co-locate all rural type mailboxes within the vicinity of the site to an off-road way location meeting current standards;
- Install R1-1 36" Stop sign for westbound traffic;
- Reset existing R2-1 35 MPH speed limit sign for eastbound 24th Ave. onto the existing post of the load limit sign further west;
- Install new R12-5 load limit sign 300 feet east of 15th St. S;
- Continue solid double yellow centerline stripe on 13th St. S closer to the intersection. Create a no passing zone in the vicinity of 24th Ave. S.
- Install new W2-2 "T" intersection ahead sign south of the crest vertical curve on 13th St. South for northbound traffic;
- Install new W2-2 "T" intersection ahead sign 500 feet north of the intersection for southbound traffic;
- Remove gravel from the west side of the gravelled driveway in the northeast corner of the intersection. Allow no wider than a 40 foot gravel approach to be perpetuated. Reseed the corner area reclaimed.

The preliminary cost estimate for the improvements at this site is \$3,350. Of this cost, approximately \$660 is eligible for FHWA funding.

### Long-Term

There are no long term improvements recommended at this location.



# ACCIDENT DATA

SITE NUMBER 8

ACCIDENT PERIOD 1986-1988

		86	87	88
		2		

## NUMBER OF ACCIDENTS BY MONTH

JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	CCT	NOV	DEC
1								1			

## NUMBER OF ACCIDENTS BY DAY OF WEEK

SUN	MON	TUES	WED	THURS	FRI	SAT
		1				1

## NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

CLEAR	RAINING	SNOWING	FOG	OTHER
1				1

## NUMBER OF ACCIDENTS BY ROAD CONDITIONS

DRY	WET	SNOWY	ICY	OTHER
1			1	

## NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

DAYLIGHT	DARK OR DUSK	DARK, LIGHTED	DARK, UNLIGHTED
1			1

## NUMBER OF ACCIDENTS BY ACCIDENT TYPE

ANGLE	R-END	FX-OBJ	PED	BACKING	SIDWYP	NON-COL	HEAD-ON	LIVESTOCK
1		1						

## NUMBER OF ACCIDENTS BY NUMBER OF INJURIES

0	1	2	3	4	5
2					

## NUMBER OF ACCIDENTS BY NUMBER OF FATALITIES

0	1	2	3	4	5
2					

YEARLY SUMMARY OF NUMBER OF INJURIES, NUMBER OF FATALITIES,  
AND NUMBER OF PROPERTY DAMAGE ONLY

	86	87	88
No. inj.			
No. fatal.			
No. P.D.O.		2	

RECOMMENDED PROGRAM  
WITH SIGHT DISTANCE INDICATOR  
CASCADE COUNTY, MONTANA  
DETERMINATION OF PRIORITY INDEX

Site Number 8

Site Description 13th Street South & 24th Avenue South

PRIORITY INDEX FOR SHORT TERM IMPROVEMENTS (S.P.I.)

From Table 6:

S.P.I. = H.I. = 35.29

PRIORITY INDEX FOR LONG TERM IMPROVEMENTS (L.P.I.)

Benefit-Cost Ratio = 0.45

B/C Index Value = 0

L.P.I. =  $0.75 \times (\text{H.I.}) + 0.25 \times (\text{B/C.I.})$

=  $0.75 \times \underline{35.29} + 0.25 \times \underline{0}$

L.P.I. = 26.47

Form for Determination of Priority Index





SITE 8: From approximately .25 miles south of 24th Ave. S looking north. The intersection is not visible due to the crest of the hill .15 miles south of the intersection where the suburban is traveling northbound. (0/15)



SITE 8: On S. 13th St. 0.15 miles south of the intersection with 24th Ave. S at the crest of the hill looking north. (0/15)









SITE 8: On 13th St. S approximately 0.1 miles north of 24th Ave. S looking south. (0/17)



SITE 8: On 24th Ave. S approximately 200'± east of S. 13th St. looking west. The intersection of 24th Ave. S and 15th St. S is approximately 100' east of where this photo was taken. (0/19)

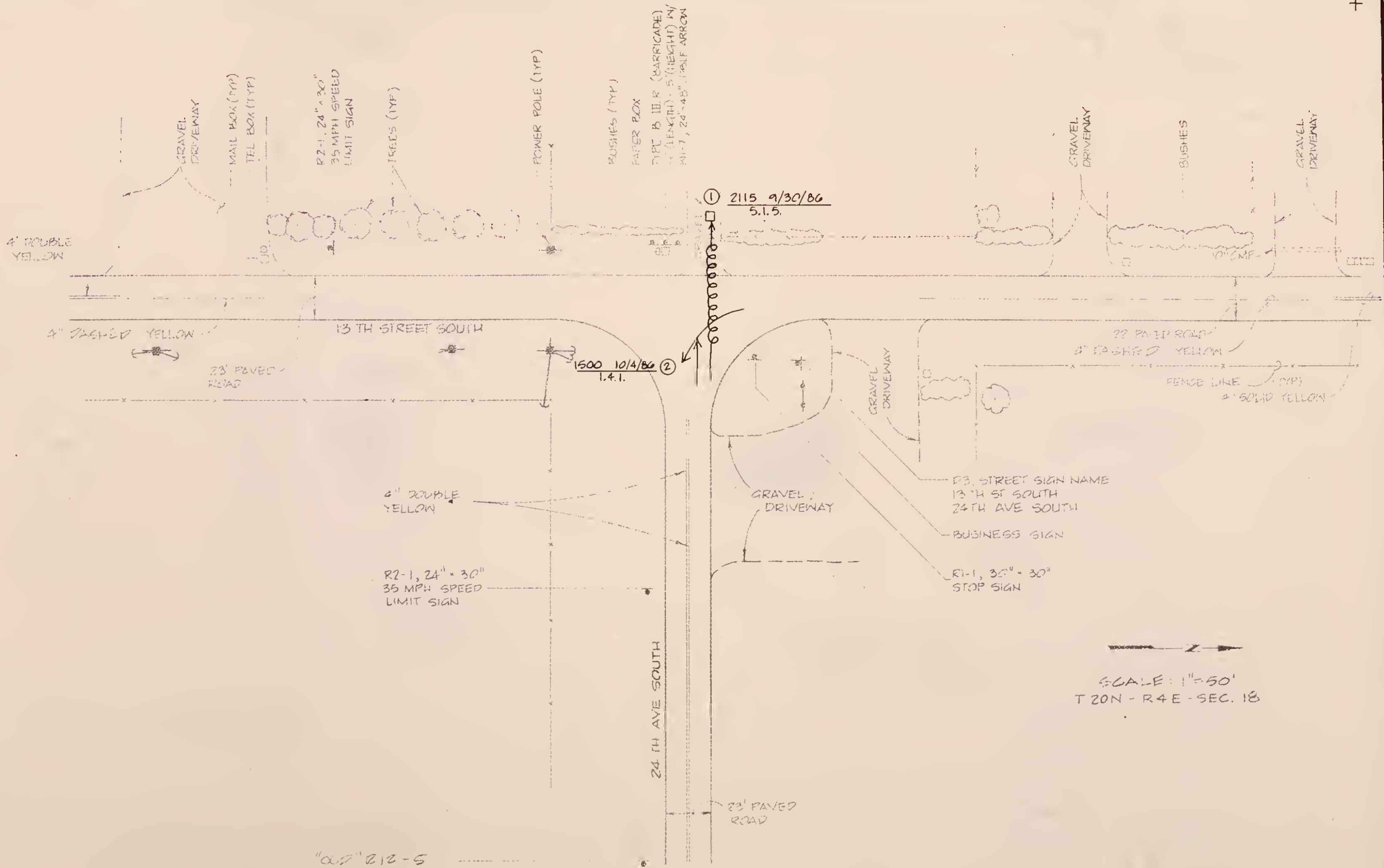












## ACCIDENT DIAGRAM

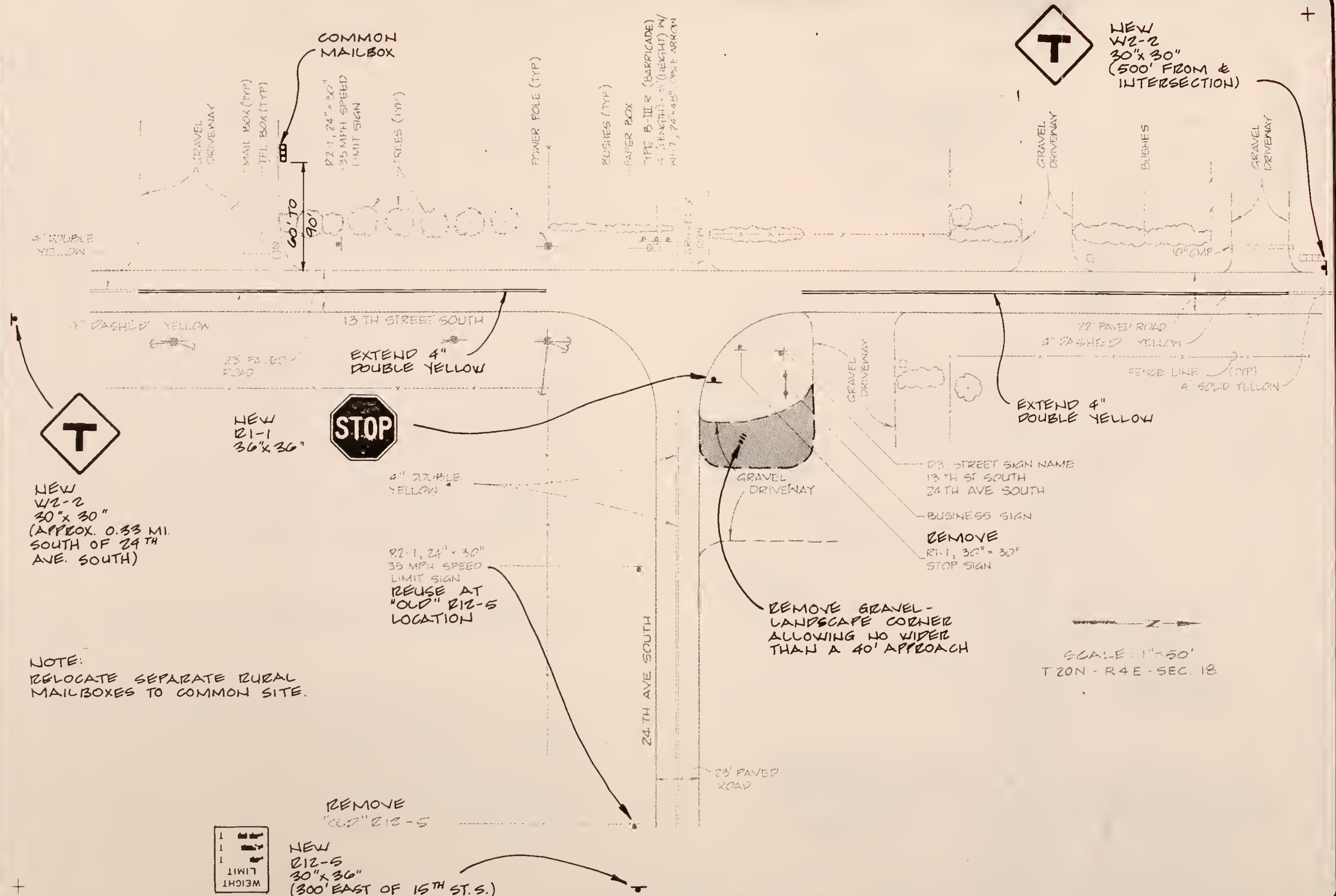
13 th ST. SOUTH & 24th AVE. SOUTH INTERSECTION

SITE 8

HKA ASSOCIATES  
ENGINEERS - PLANNERS  
2M144.103 SEPT., 1989











LOCATION NO. 11  
SMELTER AVENUE AND 10th STREET WEST INTERSECTION

GENERAL DESCRIPTION

This is an urban four legged intersection located approximately .2 miles north of the Missouri River just north of Great Falls. The suburb of Black Eagle is just to east of this site. The north, south and west legs of this intersection have been improved to urban standards complete with curb, gutter and raised center medians. The west and north legs are part of the northwest bypass route around Great Falls. The Montana Refinery is located in the southwest quadrant of the intersection. An Allied Van Lines terminal, and other commercial/industrial land use, are located just east toward Black Eagle.

EVALUATION

Traffic Volumes

The northbound and eastbound legs of this intersection are the predominant traffic volume approaches. Morning traffic near the peak hour was observed. The eastbound right and northbound left turn movements dominated. A large number of trucks were observed to leave the site eastbound, make a left U-Turn parallel to the site to a weigh scale located approximately 1/10th of a mile off site, and then return to the intersection. Also, several illegal U-Turn movements were observed to be made by eastbound traffic at the intersection. In all cases U-turn traffic accessed the commercial land use in the northwest corner of the intersection. Currently the Prospectors Casino is located on this corner. Based on information obtained in the accident reports, a restaurant/bar has been located on this corner throughout the study period.

Signing

The location was signed and lighted with a Highway Department project in the late 60's. See the condition diagram for the signs and the locations.

Accidents

A total of 14 accidents occurred during the study period. All reported accidents took place in 1986. When questioned about the lack of accidents in 1987 and 1988 the consultant was told that no other accidents were reported and it was a coincidence that all accidents occurred in one year. Based on the accident data provided, most accidents occurred mid-week when the roadway was dry during the hours of daylight. Mostly angle and rear end accidents occurred. Most of the accidents which occurred during icy roadway conditions were rear end type accidents westbound on Smelter Avenue. Several accidents

occurred due to the cross traffic interference and mid-block left turns into the adjacent commercial strip development. Several accidents occurred in the eastbound right turn only lane of Smelter Avenue and several accidents occurred due to the proximity of the commercial land use in the northwest quadrant of the intersection.

### Contributing Factors

Contributing Factors through accidents at this location are:

- Roadway conditions (icy);
- Driver inattentiveness;
- Improper lane changing;
- Improper left turns (failure to yield the right-of-way);
- Alcohol involvement;
- Improper merge.

### RECOMMENDED IMPROVEMENTS - SMELTER AVENUE & 10th STREET WEST

#### Short Term

- Improve lane use control signage especially eastbound and westbound. See the short term improvement diagram;
- Close the drive approach nearest the northwest corner of the intersection;
- Install a new street light near the west end of the median on the west leg of Smelter Avenue;
- Reinstall the street light near the south end of the median on 10th St. W. (this light pole may have been removed and the base paved over in the Montana Refinery parking lot);
- Reset the existing pedestrian gate of the refinery parking lot to be in line with the pedestrian cross walk;
- Remove and reset to standard mounting height the existing R4-7 Keep Right sign for eastbound Smelter Avenue;
- Remove the existing Type I object marker for southbound traffic at the beginning of the median on 10th St. W;
- Colocate the existing R3-7 Right Lane Must Turn Right for eastbound Smelter Avenue to the adjacent light pole;
- Provide 4" yellow stripe around all raised medians 2 feet away from raised curbs.
- Provide new D3 street name signs in the northwest, and southeast corners.

The preliminary cost estimate for the improvements at this site is \$11,460. Of this cost, approximately \$920 is eligible for FHWA funding.

### Long Term

The following long term improvements are recommended to improve the safety of this location:

- Provide additional street lighting on the north and east legs of the site;
- Provide additional signal heads mounted on existing span wire poles for northbound and southbound traffic;
- Acquire additional right-of-way to install a eastbound to southbound free right turn only lane with an adequate acceleration distance along 10th St. W.

The preliminary cost estimate for the improvements at this site is \$72,680. Of this cost, approximately \$280 is eligible for FHWA funding.



# ACCIDENT DATA

SITE NUMBER 11

ACCIDENT PERIOD 1936 - 1938

		86	87	88
		14		

## NUMBER OF ACCIDENTS BY MONTH

JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
	2	1	1	1	5	2	1	1			

## NUMBER OF ACCIDENTS BY DAY OF WEEK

SUN	MON	TUES	WED	THURS	FRI	SAT
	4	2	4	1		3

## NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

CLEAR	RAINING	SNOWING	FOG	OTHER
12				4

## NUMBER OF ACCIDENTS BY ROAD CONDITIONS

DRY	WET	SNOWY	ICY	OTHER
11	1		2	

## NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

DAYLIGHT	DARK OR DUSK	DARK, LIGHTED	DARK, UNLIGHTED
11	1	2	

## NUMBER OF ACCIDENTS BY ACCIDENT TYPE

ANGLE	R-END	FX-OBJ	PED	BACKING	SIDWYP	NON-COL	HEAD-ON	LIVESTOCK
6	6	2						

## NUMBER OF ACCIDENTS BY NUMBER OF INJURIES

0	1	2	3	4	5
12	1	1			

## NUMBER OF ACCIDENTS BY NUMBER OF FATALITIES

0	1	2	3	4	5
14					

## YEARLY SUMMARY OF NUMBER OF INJURIES, NUMBER OF FATALITIES, AND NUMBER OF PROPERTY DAMAGE ONLY

		36	87	88
No. inj.		2		
No. fatal.				
No. P.D.O.		2		

RECOMMENDED PROGRAM  
WITH SIGHT DISTANCE INDICATOR  
CASCADE COUNTY, MONTANA  
DETERMINATION OF PRIORITY INDEX

Site Number 11

Site Description Smelter Avenue & 10th St. North Intersection

PRIORITY INDEX FOR SHORT TERM IMPROVEMENTS (S.P.I.)

From Table 6:

S.P.I. = H.I. = 29.81

PRIORITY INDEX FOR LONG TERM IMPROVEMENTS (L.P.I.)

Benefit-Cost Ratio = 0.17

B/C Index Value = 0

L.P.I. =  $0.75 \times (\text{H.I.}) + 0.25 \times (\text{B/C.I.})$

=  $0.75 \times \underline{29.81} + 0.25 \times \underline{0}$

L.P.I. = 22.36

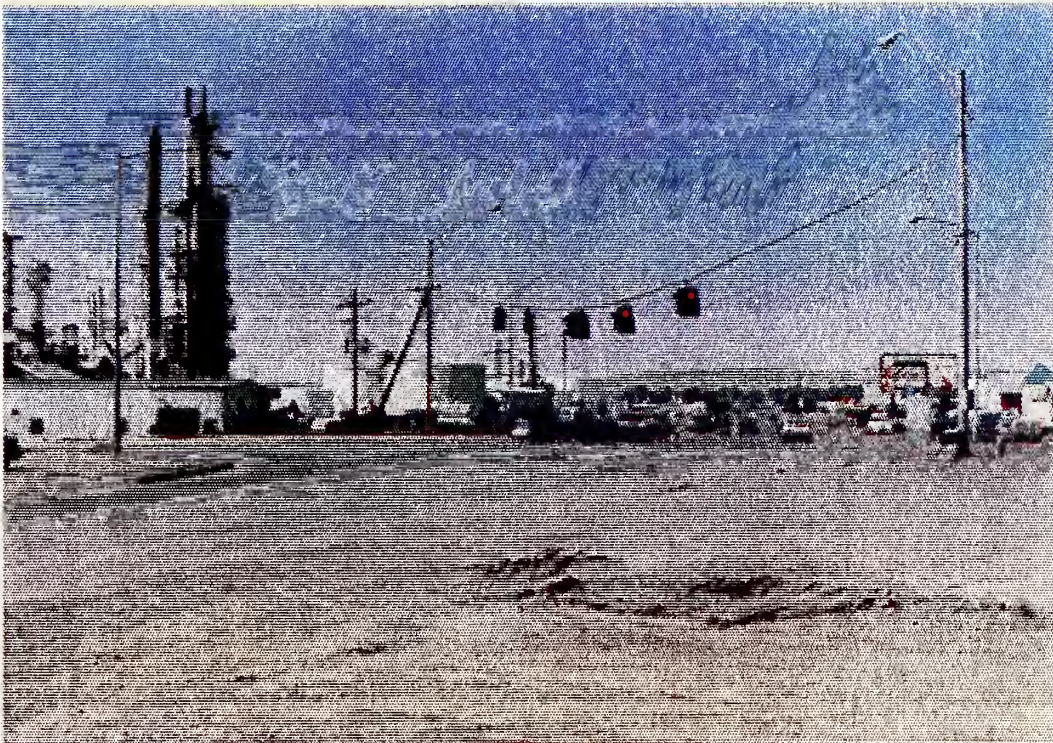
Form for Determination of Priority Index







SITE 11: Smelter Avenue from approximately 10th Street looking west. There is a great deal of semi-truck activity on the east leg of the intersection due to; a) North American Van Lines being located at the northwest corner of Smelter Avenue and 11th, and b) North American's semi-truck weigh scale in the southwest corner of their site. (2/6)



SITE 11: From the north side of Smelter Avenue at the Great Falls/Ravre guide sign looking west southwest. Notice the pickup truck behind the median turning eastbound to southbound. (2/6)









SITE 11: On 10th Street North beneath the overhead sign bridge 500' south of Smelter Avenue looking north. This photo is taken from the driver's eye height in the right outside lane. (2/9)



SITE 11: Taken on the south leg of 10th Street North approximately 80' south of the south end of the median looking northwest through the pedestrian gate of the refinery parking lot. This gate is lined up approximately across 10th Street North from the refinery office door. Notice the two types of pedestrian crosswalk striping just south of the median. (2/10)









SITE 11: Taken from the landscaped median in the southwest corner of the intersection looking south down 10th Street North. (2/13)



SITE 11: On Smelter Avenue near the 10th Street bridge weight limit 10 tons sign looking east toward Black Eagle. The light pole on the extreme left is on the northeast corner of 8th Street north and Smelter Avenue. (2/14)

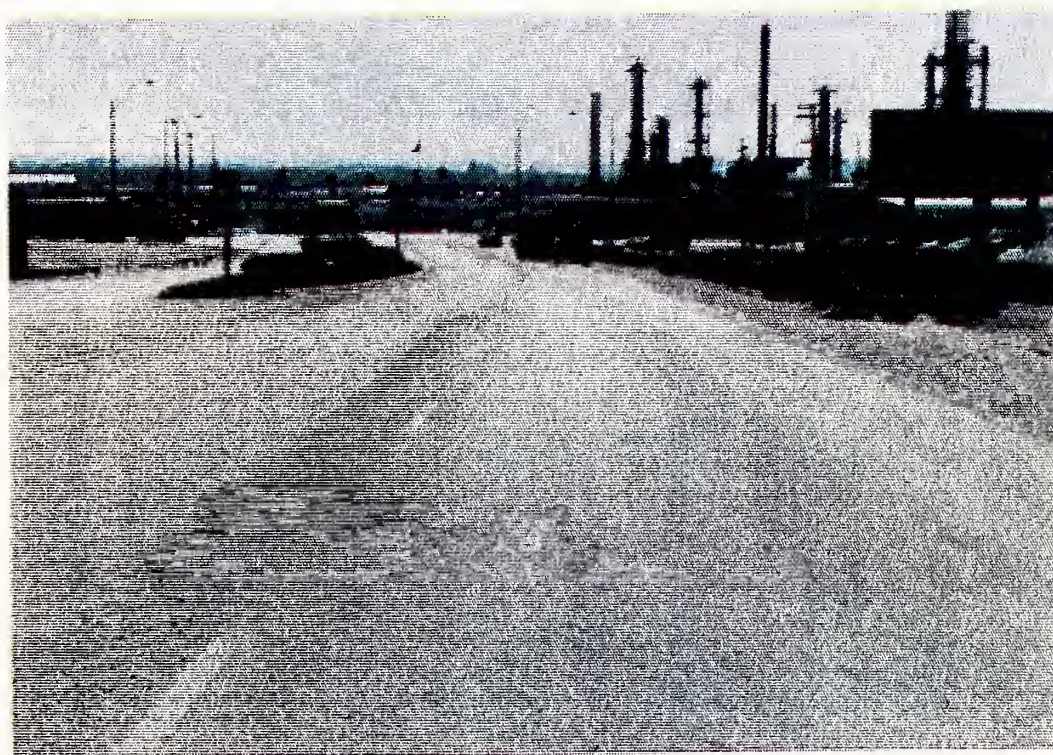








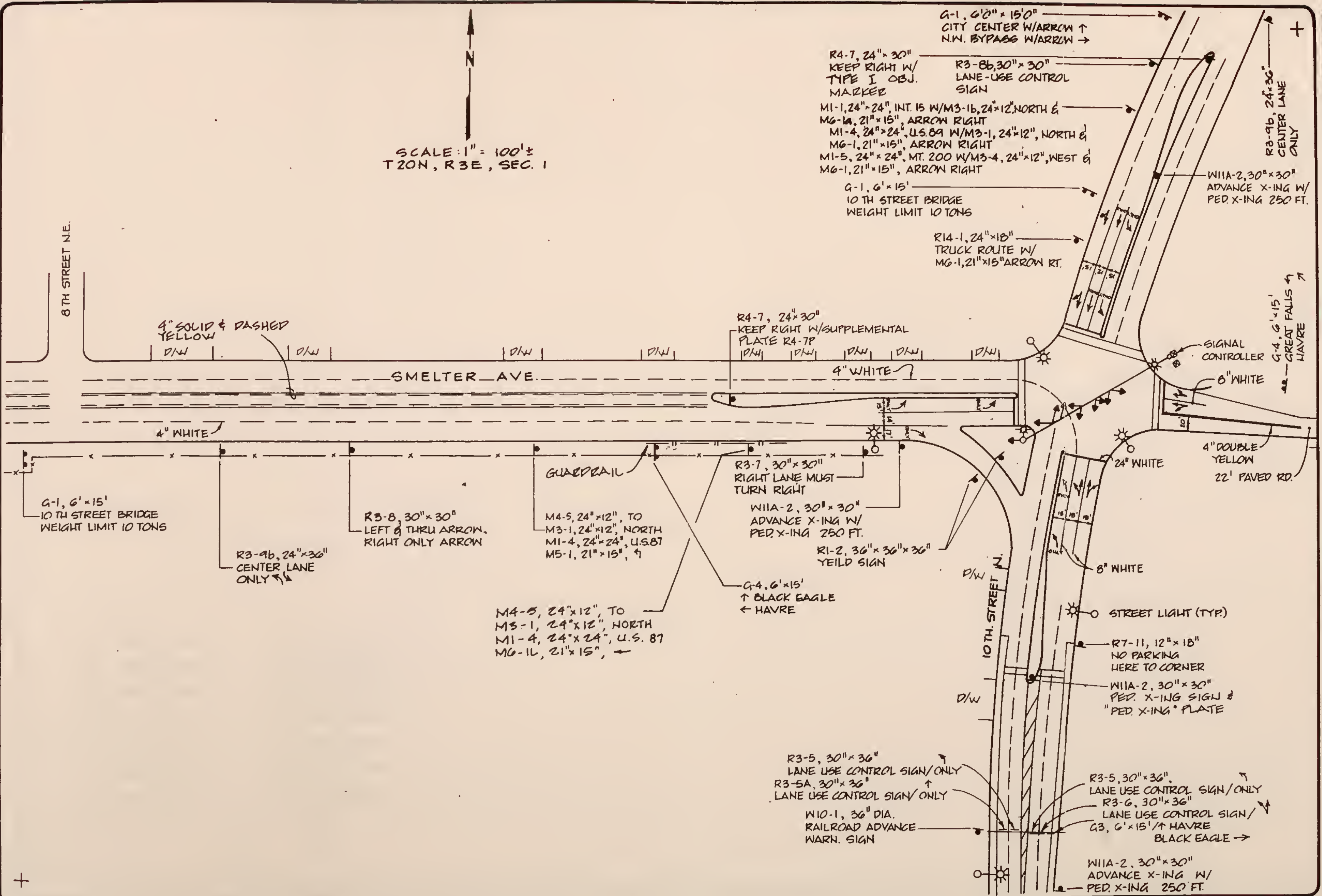
SITE 11: On Smelter Avenue opposite the "To U.S. 87 -" sign looking east. Notice the driveway spacing in the northwest quadrant of the intersection. (2/16)



SITE 11: On 10th Street North approximately 150' north of the north end of the median looking south. Notice there is no roadway lighting between Smelter and 25th Avenue NE. (2/19)







SITE 11

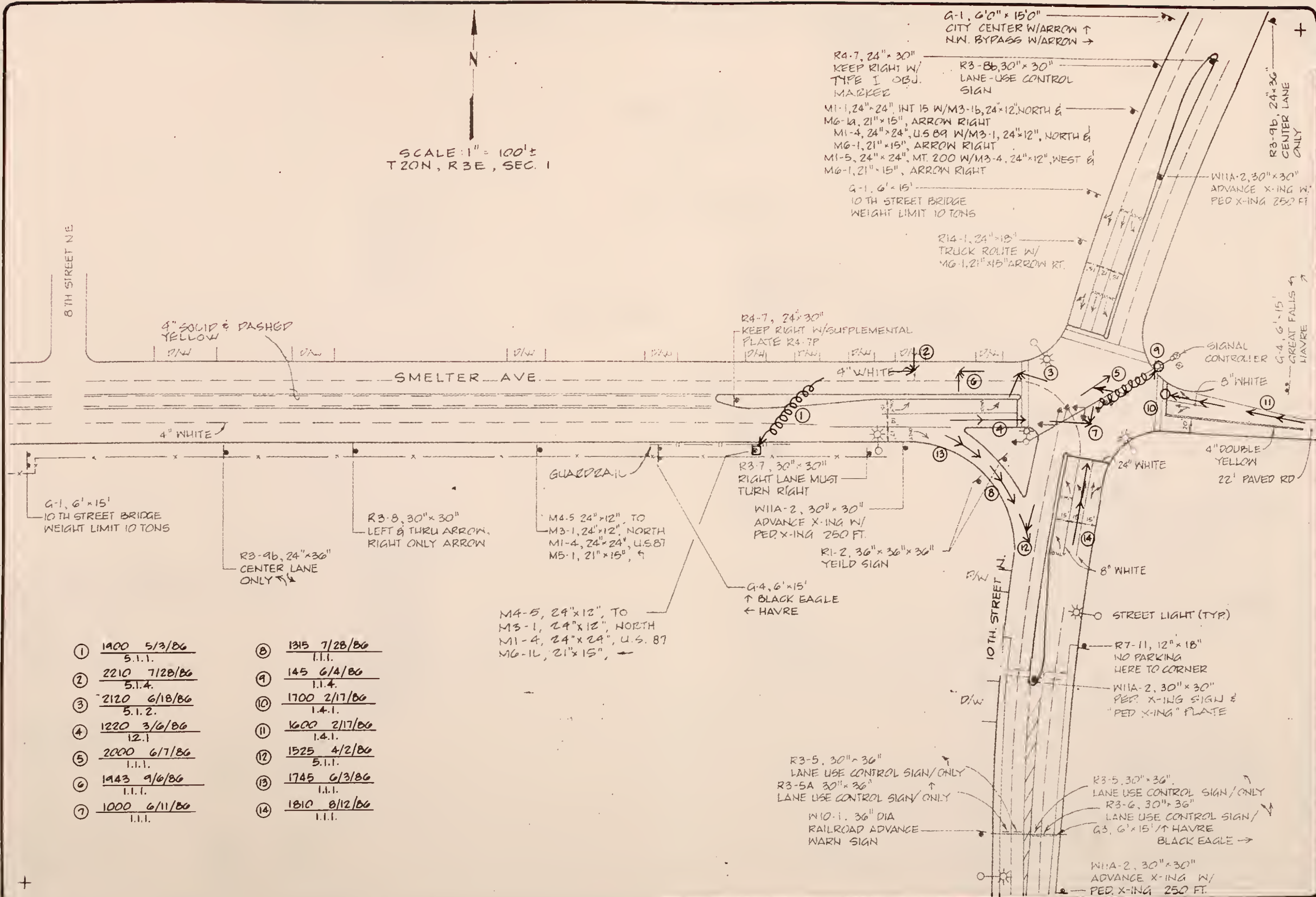
**HKA ASSOCIATES**  
 ENGINEERS - PLANNERS  
2M144.103 SEPT., 1989

## CONDITION DIAGRAM

### SMELTER AVE. & 10th ST. NORTH INTERSECTION







- |                          |                          |
|--------------------------|--------------------------|
| ① 1900 5/3/86<br>5.1.1.  | ⑧ 1315 7/28/86<br>1.1.1. |
| ② 2210 7/28/86<br>5.1.4. | ⑨ 145 6/4/86<br>1.1.4.   |
| ③ 2120 6/18/86<br>5.1.2. | ⑩ 1700 2/17/86<br>1.4.1. |
| ④ 1220 3/6/86<br>12.1    | ⑪ 1600 2/17/86<br>1.4.1. |
| ⑤ 2000 6/7/86<br>1.1.1.  | ⑫ 1525 4/2/86<br>5.1.1.  |
| ⑥ 1443 9/6/86<br>1.1.1.  | ⑬ 1745 6/3/86<br>1.1.1.  |
| ⑦ 1000 6/11/86<br>1.1.1. | ⑭ 1810 8/12/86<br>1.1.1. |

















LOCATION NO. 14  
18th AVE. SW & 14th ST. SW/FLOOD ROAD INTERSECTION

GENERAL DESCRIPTION

This is a rural, paved, two lane-two way, "T" intersection in the southwest quadrant of Great Falls. The locations accessible via Flood Road from the south, 18th Ave. SW from the east, and 13th Ave. SW from the north. Suburban land use is located approximately 700' to the east and 400' to the north.

EVALUATION

Traffic Volumes

14th St. SW/Flood Road is the predominant traffic volume street. During the time observed, the northbound right turn and westbound left turn movements predominated at the intersection. On a daily basis approximately 1600 vehicles enter the intersection from all legs.

Signing

All legs of the intersection are signed for 30 MPH speed limits entering the site. There is metal W beam guardrail between a 4 foot ± wide shoulder and the traveled way along the east side of 14th St. SW. This guardrail includes Type OM-3 object markers where appropriate. No "D3" type street name signs are present at this intersection. There is a northbound school bus stop ahead sign located near the northeast corner of the intersection. Numerous rural type mailboxes and power poles line all legs of the intersection. Adjacent parallel cross streets are 16th and 17th Avenues SW are located within 600 feet and 300 feet of the intersection respectively. There is a railroad crossing on 18th Ave. SW approximately 610 feet east of 14th St. SW. The railroad crossing is appropriately signed, however no pavement markings were apparent for the railroad crossing.

Accidents

Three accidents occurred at this location within the study period. All accidents occurred on Fridays or Saturdays during fall or winter months. All accidents were fixed object type with two out of three occurring during hours of darkness. One occurred during icy roadway conditions.

Contributing Factors

Contributing factors to accidents at this location were:

- Driver inexperience;
- Speed too fast for conditions;
- Alcohol involvement.

It is interesting to note at this location that accidents occurred to vehicles coming from all three directions.

#### RECOMMENDED IMPROVEMENTS - 18th AVE. SW & 14th ST. SW

##### Short Term

The following short term improvements are recommended to improve the safety of this location.

- Reset the existing 30" Stop sign closer to the intersection;
- Add stop bar for westbound 18th Ave. SW;
- Trim trees and brush located behind the guardrail on the south leg of 14th St. SW;
- Provide design type "D" delineators at each approach on the west side of 14th St. SW south of 18th Ave. SW;
- Install a W2-2 side road sign on the north and south legs of the intersection;
- Install new D-3 black on yellow street name supplemental plates on all existing and new intersection ahead warning signs;
- Add new 4" white edge stripes, and new 4" double yellow centerline stripes on 14th St. SW;
- Install new railroad crossing pavement markings on 18th Avenue SW;
- Relocate the existing S3-1 School Bus Ahead sign to the top of the southern most bridge pier in the north leg of 14th St. SW;
- Install new D-3 street name signs on the reset stop sign post.

The preliminary cost estimate for the improvements at this site is \$3,190. Of this cost, approximately \$990 is eligible for FHWA funding.

##### Long Term

The following long term improvements are recommended to improve the safety of this intersection.

- Replace the existing WB guardrail and object markers on the east side of 14th St. SW with curb, gutter and sidewalk;
- Extend curb, gutter and sidewalk along 18th Ave. SW from 14th St. SW to across the railroad track to the suburban development near Treasure State Drive;
- Install new curb, gutter and sidewalk along the west side of 14th St. SW from the Airway Hotel north to 16th Ave. SW.

The preliminary cost estimate for the improvements at this site is \$37,100. Of this cost, approximately \$1,210 eligible for FHWA funding.



# ACCIDENT DATA

SITE NUMBER 14

ACCIDENT PERIOD 1986 - 1988

		86	87	88
		1	1	1

## NUMBER OF ACCIDENTS BY MONTH

JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
									1	1	1

## NUMBER OF ACCIDENTS BY DAY OF WEEK

SUN	MON	TUES	WED	THURS	FRI	SAT
					2	1

## NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

CLEAR	RAINING	SNOWING	FOG	OTHER
				2

## NUMBER OF ACCIDENTS BY ROAD CONDITIONS

DRY	WET	SNOWY	ICY	OTHER
2			1	

## NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

DAYLIGHT	DARK OR DUSK	DARK, LIGHTED	DARK, UNLIGHTED
1	1		1

## NUMBER OF ACCIDENTS BY ACCIDENT TYPE

ANGLE	R-END	FX-OBJ	PED	BACKING	SIDWYP	NON-COL	HEAD-ON	LIVESTOCK
		3						

## NUMBER OF ACCIDENTS BY NUMBER OF INJURIES

0	1	2	3	4	5
3					

## NUMBER OF ACCIDENTS BY NUMBER OF FATALITIES

0	1	2	3	4	5
3					

## YEARLY SUMMARY OF NUMBER OF INJURIES, NUMBER OF FATALITIES, AND NUMBER OF PROPERTY DAMAGE ONLY

	86	87	88
No. inj.			
No. fatal.			
No. P.D.O.	1	1	1

RECOMMENDED PROGRAM  
WITH SIGHT DISTANCE INDICATOR  
CASCADE COUNTY, MONTANA  
DETERMINATION OF PRIORITY INDEX

Site Number 14  
Site Description 18th Ave SW & 14th St SW/Flood Rd Intersection

PRIORITY INDEX FOR SHORT TERM IMPROVEMENTS (S.P.I.)

From Table 6:

S.P.I. = H.I. = 33.24

PRIORITY INDEX FOR LONG TERM IMPROVEMENTS (L.P.I.)

Benefit-Cost Ratio = 0.01

B/C Index Value = 0

L.P.I. =  $0.75 \times (\text{H.I.}) + 0.25 \times (\text{B/C.I.})$

=  $0.75 \times \underline{33.24} + 0.25 \times \underline{0}$

L.P.I. = 24.93

Form for Determination of Priority Index





SITE 14: Flood Road approximately 500' south of 18th Avenue South looking north. A northbound no passing zone begins at this location. (4/14)



SITE 14: Flood Road approximately 500' north of 18th Avenue Southwest looking south. This photo is taken approximately from the north end of guardrail on the east side of Flood Road. The 18th Avenue Southwest intersection is not yet visible from this location. (4/16)







SITE 14: From the southwest corner 17th Avenue Southwest and Flood Road looking southeast. (4/18)

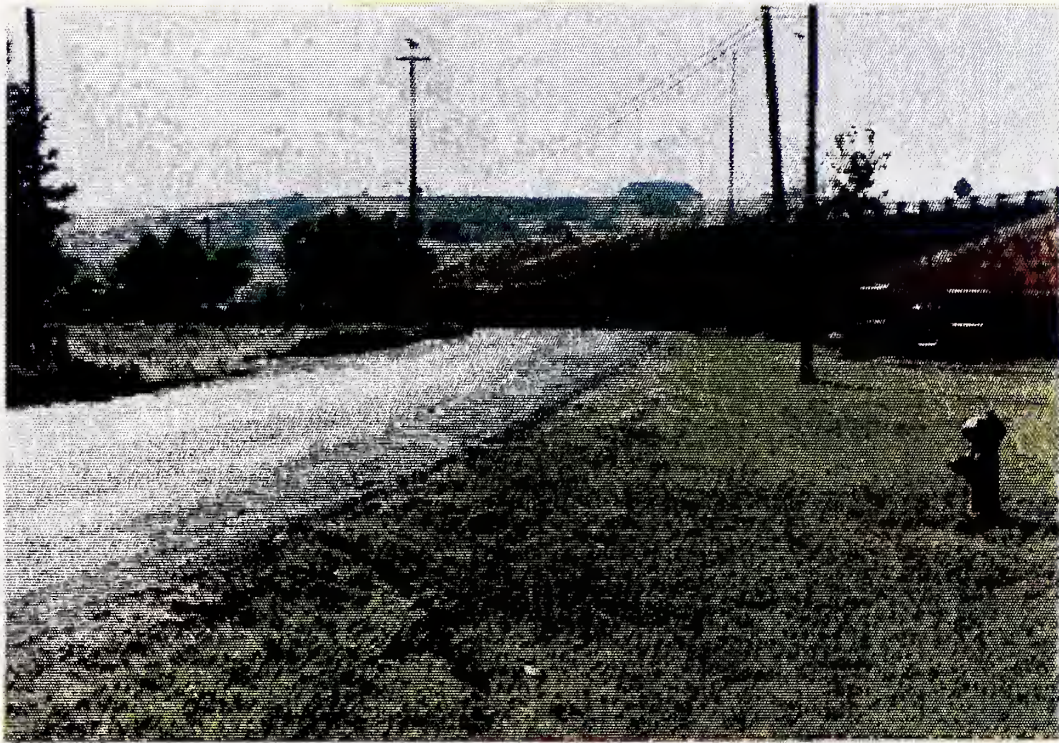


SITE 14: From the west side of Flood Road approximately 150' south of 18th Avenue Southwest looking north. Notice the position of the stopped vehicle relative to the westbound stop sign. (4/19)









SITE 14: On 18th Avenue Southwest looking west. (4/21)



SITE 14: From 18th Avenue Southwest, 80' east of the railroad crossing looking west from the approximate drivers eye height. (4/23)



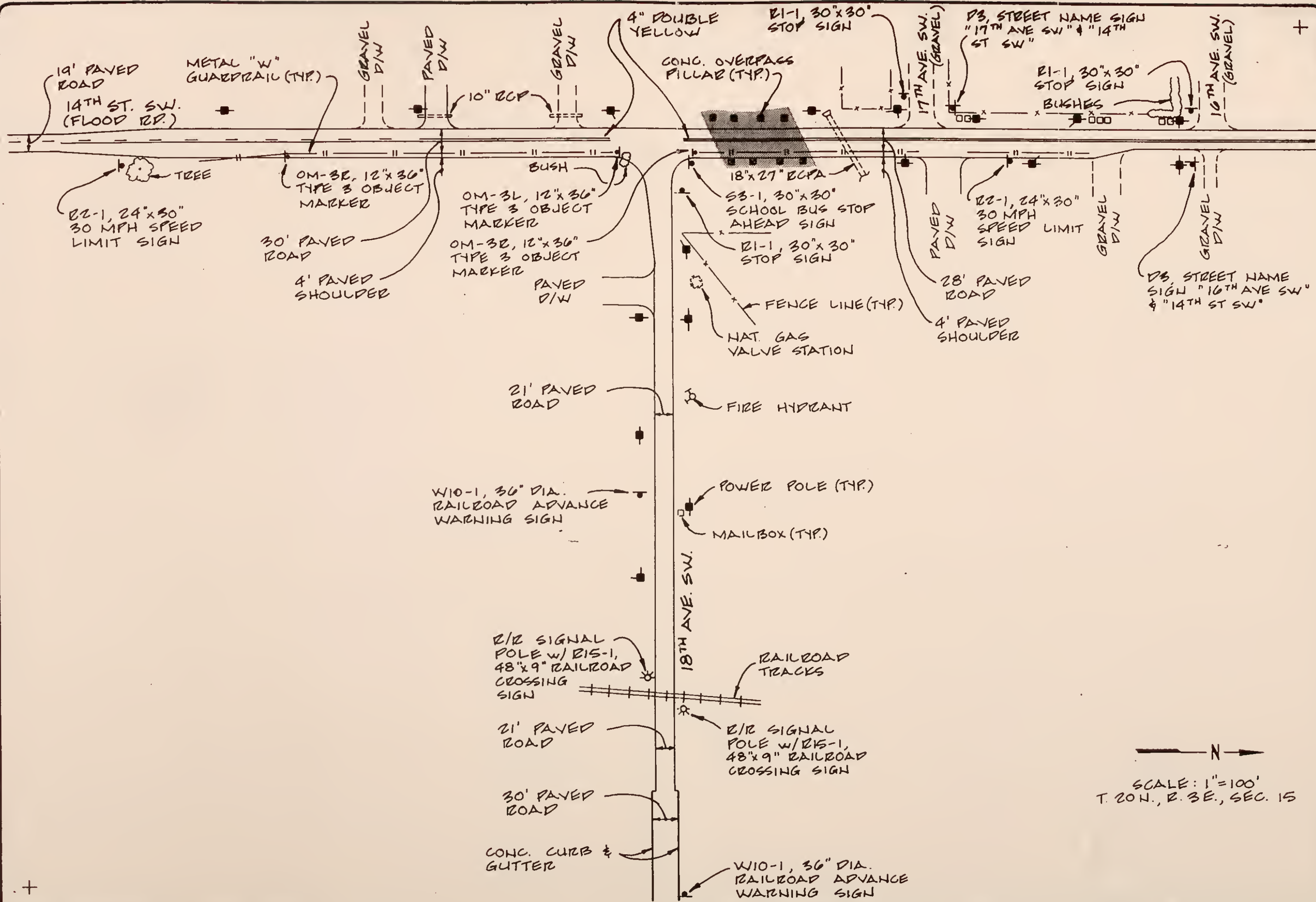




SITE 14: Flood Road approximately 600' south of the highway overpass looking north. Notice the speed limit sign is barely visible on the right. (5/20)











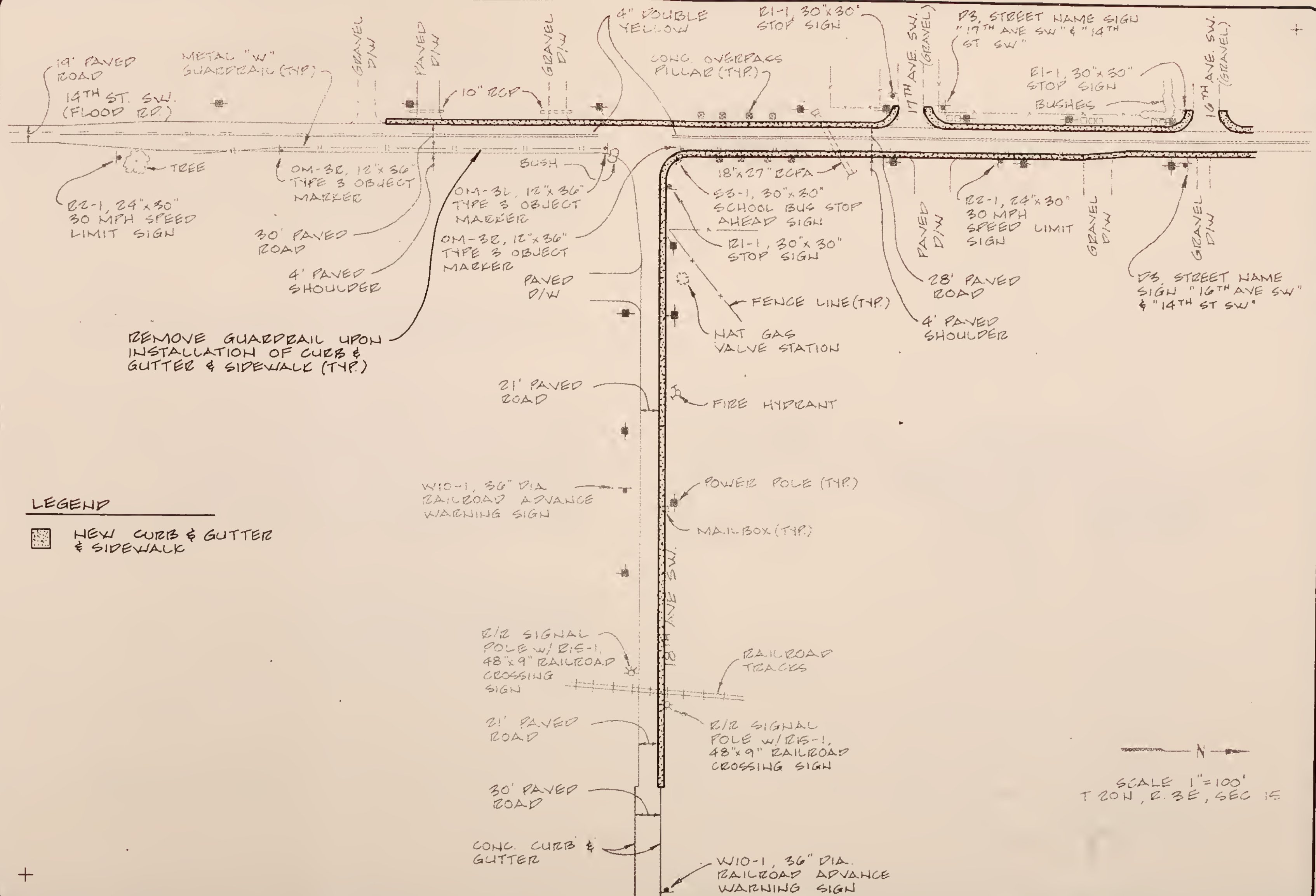












**RECOMMENDED IMPROVEMENTS (LONG TERM)**  
18th AVE. SW. & 14th ST. SW./FLOOD RD. INTERSECTION

**SITE 14**

**HKA ASSOCIATES**  
ENGINEERS - PLANNERS  
2M144.103 SEPT., 1989





LOCATION NO. 15  
FOX FARM ROAD & 45th AVENUE SOUTH/JONES ROAD

GENERAL DESCRIPTION

This site is a rural, two lane-two way, four legged, Stop sign controlled intersection near the south urban boundary of Great Falls. Fox Farm Road is a through street and is paved. 45th Avenue S. is Stop sign controlled and is a gravel road on both legs. This site is located near the crest of a hill descending to the north, east, and west. A northbound passing zone begins approximately 100 feet north of this location. Both legs of 45th Avenue S. slope upward toward Fox Farm Road.

EVALUATION

Traffic Volumes

Fox Farm Road is the predominant traffic volume street with a 1989 observed ADT of just over 1200. Neither leg of 45th Ave. S/Jones Road were observed to have much traffic demand.

Signing

All legs of this intersection are signed for 35 MPH speed limits. There is a W12-1 Cross Road sign for northbound Fox Farm Road traffic located approximately 650 feet south of 45th Ave. S. Fox Farm Road is striped with a double yellow centerline stripe from the crest of the hill with 45th Ave. S to the south. A northbound passing zone begins just beyond the crest of the hill approximately 100 feet north of 45th Ave. S and extends to the north. Both legs of Fox Farm Road have R2-1 35 MPH speed limit signs for traffic leaving the site in both directions of travel.

Accidents

A total of five accidents occurred during the study period at this location. All occurred during hours of darkness. There were two fixed object accidents, one angle accident, one head-on accident, and one vehicle leaving the roadway. Injuries were sustained only in two accidents. Most accidents occurred during dry roadway conditions.

Contributing Factors

Major factors contributing to accidents at this location are:

- Alcohol involvement;
- Driver inexperience;
- Reckless driving (passing in a No Passing Zone);

- Sight distance due to the crest vertical curve in the north leg of the intersection;
- Roadway condition (icy);
- Inattentive driving for roadway conditions.

## RECOMMENDED IMPROVEMENTS

### Short Term

The following short term improvements are recommended to improve the safety of this location:

- Install a W12-1 Cross Road sign 500' north of the intersection;
- Install new D-3 black on yellow street name supplemental plates on all existing and new intersection ahead or stop ahead warning signs;
- Install design type "D" delineators in all corners of the intersection;
- Install new 48" R1-1 Stop sign for eastbound and westbound traffic;
- Install new W3-1a Stop Ahead signs on 45th Ave. S. 700' in advance of Fox Farm Road.
- Reset existing R2-1 35 MPH speed limit sign in the southwest quadrant of the intersection 400 feet further south;
- Relocate and colocate mailboxes to MDOH standard mailbox turnout;
- Install a new D-3 street name sign on the new stop sign post in the southwest corner of the intersection.
- Replace existing R12-5 weight limit sign with current R12-5 sign face.

The preliminary cost estimate for the improvements at this site is \$2,420. Of this cost, approximately \$1,840 is eligible for FHWA funding.

### Long-Term

There are no long term improvements recommended at this location.

# ACCIDENT DATA

SITE NUMBER 15

ACCIDENT PERIOD 1986-1988

		86	87	88
		3	1	1

## NUMBER OF ACCIDENTS BY MONTH

JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
			2		1						

## NUMBER OF ACCIDENTS BY DAY OF WEEK

SUN	MON	TUES	WED	THURS	FRI	SAT
2			1		2	

## NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

CLEAR	RAINING	SNOWING	FOG	OTHER
2		1		2

## NUMBER OF ACCIDENTS BY ROAD CONDITIONS

DRY	WET	SNOWY	ICY	OTHER
3	1		1	

## NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

DAYLIGHT	DARK OR DUSK	DARK, LIGHTED	DARK, UNLIGHTED
			5

## NUMBER OF ACCIDENTS BY ACCIDENT TYPE

ANGLE	R-END	FX-OBJ	PED	BACKING	SIDWYP	NON-COL	HEAD-ON	LIVESTOCK
17/PCN		2				1	1	

## NUMBER OF ACCIDENTS BY NUMBER OF INJURIES

0	1	2	3	4	5
3		2			

## NUMBER OF ACCIDENTS BY NUMBER OF FATALITIES

0	1	2	3	4	5
5					

## YEARLY SUMMARY OF NUMBER OF INJURIES, NUMBER OF FATALITIES, AND NUMBER OF PROPERTY DAMAGE ONLY

	86	87	88
No. inj.	2		
No. fatal.			
No. P.D.O.	1	1	1



RECOMMENDED PROGRAM  
WITH SIGHT DISTANCE INDICATOR  
CASCADE COUNTY, MONTANA  
DETERMINATION OF PRIORITY INDEX

Site Number 15

Site Description Fox Farm Road & 45th Avenue South

PRIORITY INDEX FOR SHORT TERM IMPROVEMENTS (S.P.I.)

From Table 6:

S.P.I. = H.I. = 53.00

PRIORITY INDEX FOR LONG TERM IMPROVEMENTS (L.P.I.)

Benefit-Cost Ratio = 5.55

B/C Index Value = 36

L.P.I. =  $0.75 \times (\text{H.I.}) + 0.25 \times (\text{B/C.I.})$

=  $0.75 \times \underline{53.00} + 0.25 \times \underline{36}$

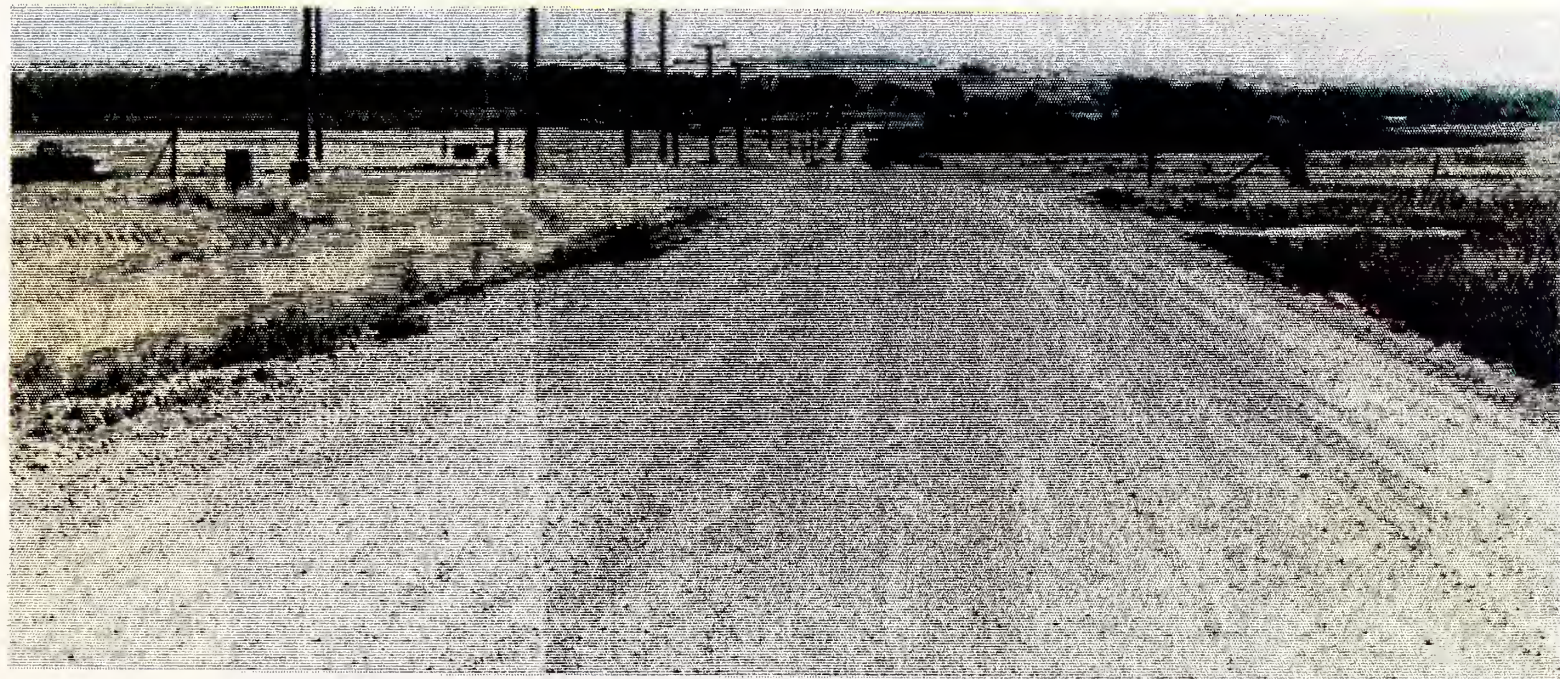
L.P.I. = 48.75

Form for Determination of Priority Index





SITE 15: On 45th Avenue SW approximately 750' west of Fox Farm Road looking east. Notice the intersection is not visible due to the crest of the hill. (4/4)



SITE 15: On 45th Avenue SW approximately 200' west of Fox Farm Road looking northeast thru southeast. (4/5+6)









SITE 15: 45th Avenue SW approximately 300' east of Fox Farm Road where the Fox Farm Road pavement becomes visible. Taken from the drivers eye height looking west. Due to the cut slope in advance of Fox Farm Road mainline vehicles can only be seen for a short time immediately at the intersection. The stop sign and intersection is obscured from the drivers view when going up the hill in the foreground. (4/8)



SITE 15: Fox Farm Road south of 45th Avenue SW looking north. From this location cars temporarily drop out of sight in advance of 45th Avenue SW and then reappear just before crossing 45th Avenue SW due to the sag vertical curve approximately 400' south of 45th Avenue SW. (4/9)



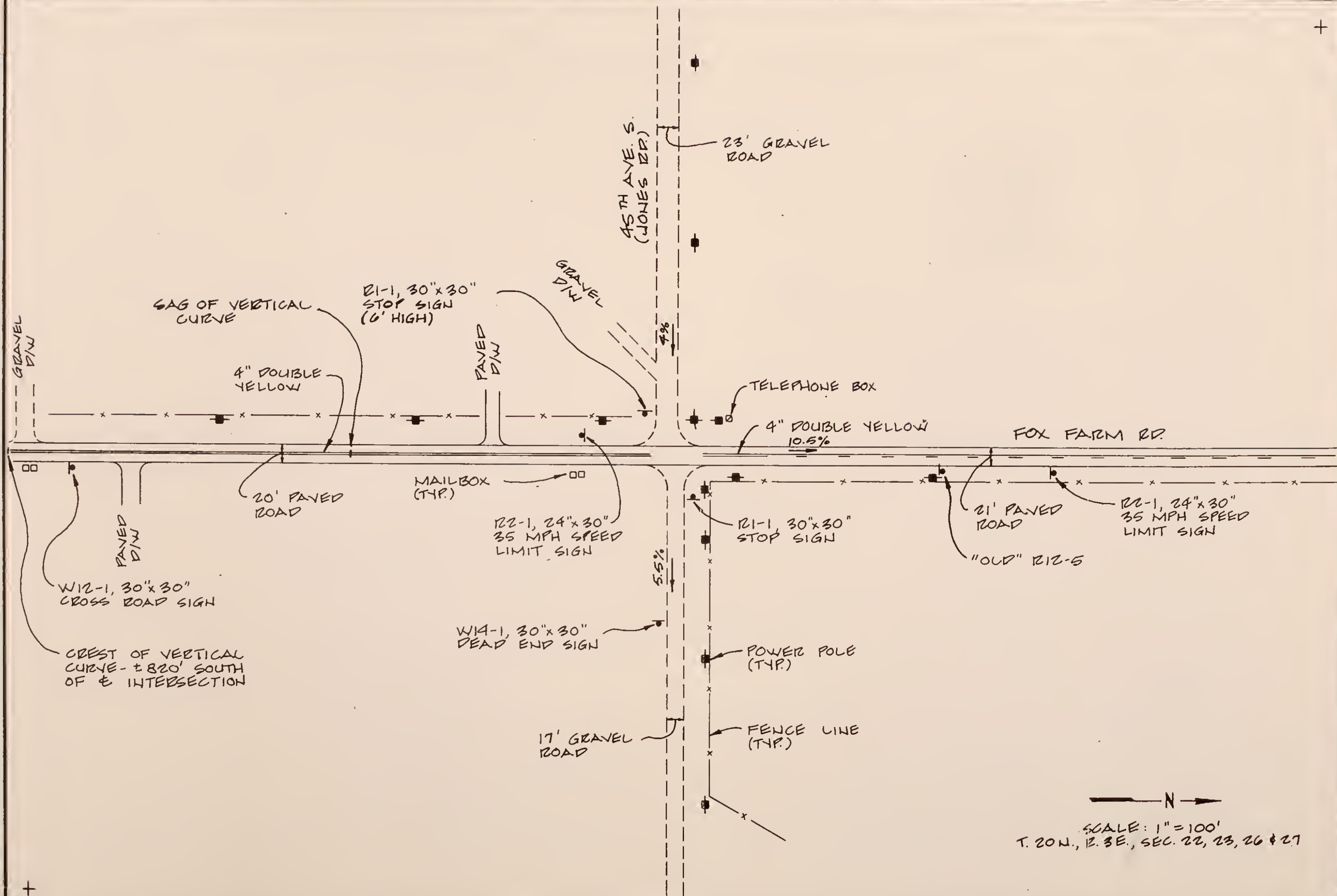




SITE 15: Fox Farm Road approximately 400' north of 45th Avenue SW looking south. (4/12)







# **CONDITION DIAGRAM**

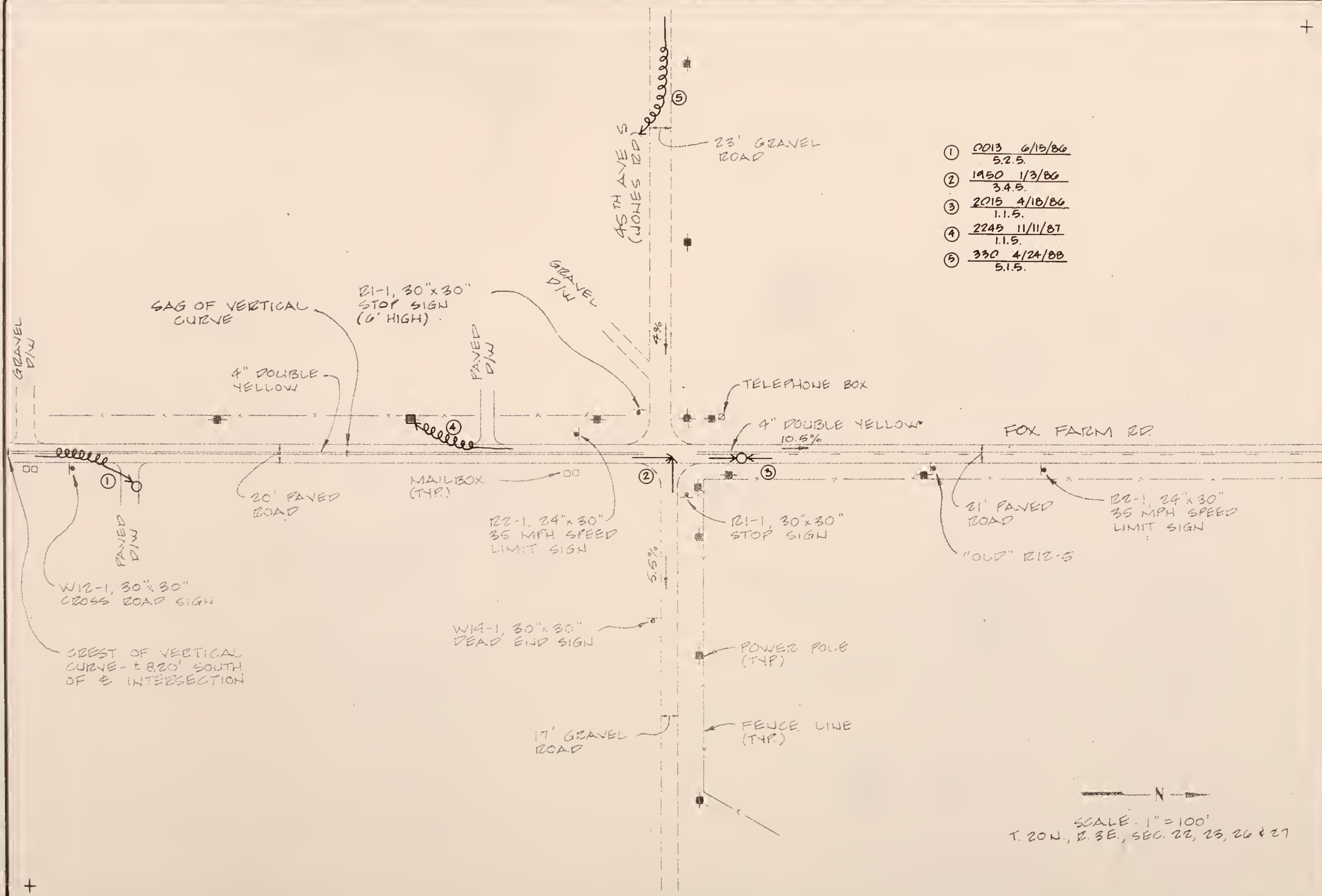
FOX FARM RD. & 45th AVE. SW. INTERSECTION

SITE 15

H&M ASSOCIATES  
ENGINEERS - PLANNERS  
2M144.103 SEPT., 1989







- ① 0013 6/15/86  
5.2.5.
- ② 1950 1/3/86  
3.4.5.
- ③ 2015 4/18/86  
1.1.5.
- ④ 2245 11/11/87  
1.1.5.
- ⑤ 330 4/24/88  
5.1.5.

**ACCIDENT DIAGRAM**  
**FOX FARM RD. & 45th AVE. SW. INTERSECTION**

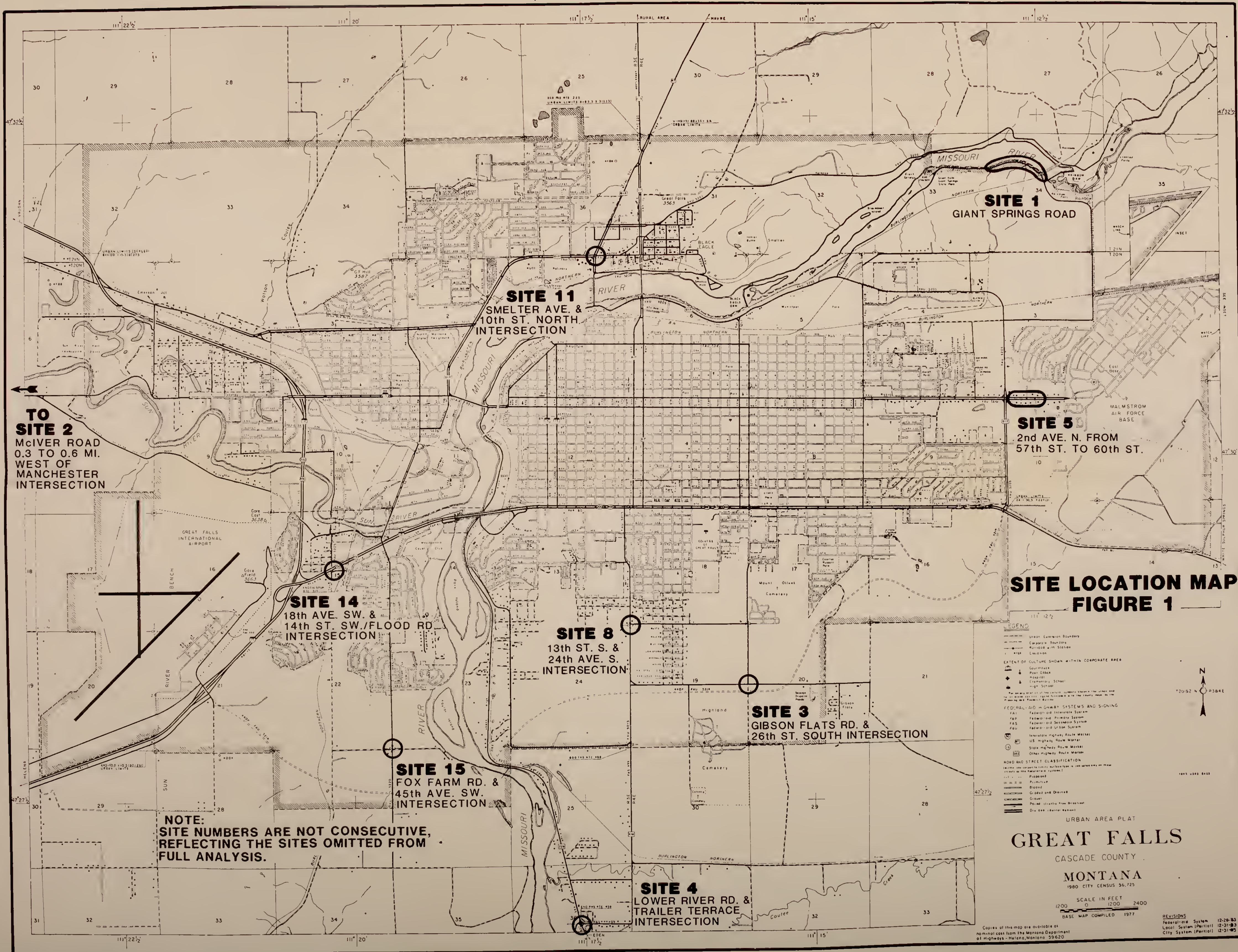












**SITE LOCATION MAP  
FIGURE 1**

- LEGEND**
- Urban Limits Boundary
  - Corporate Boundary
  - Highway with Station
  - Water
  - Location
- EXTENT OF CULTURE SHOWN WITHIN CORPORATE AREA**
- Cemetery
  - Post Office
  - High School
  - Elementary School
  - High School
- FEDERAL AID IN HIGHWAY SYSTEMS AND SIGNING**
- FAS Federal-aid Interstate System
  - FAS Federal-aid Primary System
  - FAS Federal-aid Secondary System
  - FAS Federal-aid Urban System
  - US Highway Route Marker
  - State Highway Route Marker
  - Other Highway Route Marker
- ROAD AND STREET CLASSIFICATION**
- Interstate
  - Primary
  - Secondary
  - Urban
  - Proposed
  - Graded and Drained
  - Gravel
  - Paved (except from Gravel)
  - Dirt (except from Gravel)

URBAN AREA PLAT  
**GREAT FALLS**  
CASCADE COUNTY  
**MONTANA**  
1980 CITY CENSUS 36,725  
SCALE IN FEET  
1200 0 1200 2400  
BASE MAP COMPILED 1977

Copies of this map are available at nominal cost from the Montana Department of Highways - Helena, Montana 59620

**REVISIONS**

Revision	System	Date
12-26-83	Federal-aid System	12-26-83
12-31-83	Local System (Partial)	12-31-83
12-31-83	City System (Partial)	12-31-83









